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Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

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The Ship of the Future

WE have always said that when plastics succeed in the chemical industry and in engineering, then the welfare of our industry is assured. This is somewhat exaggerating the matter, for plastics have long succeeded in the electrical and other industries, so that plastics have little to fear for the future. What we meant was that the problems in the chemical and engineering industries were so difficult that their solution would mean a further great advance. A good many of their problems have already been solved, but there is much more to be done.

If we narrow down the sphere of action still more there will be many who consider that of the whole engineering industry, that section which deals with shipbuilding presents the most difficult problems of all. Certainly the plastics industry has found shipbuilders a tough lot to approach. Certainly the impact of plastics on shipbuilding has been woefully small, and while no doubt some of the swagger liners have introduced plastic-panelled bars and decorations and table tops and lavatory seats, and a plastic gear or wheel has here and there been installed for experimental purposes, yet we have all felt that this great market has, by and large, so far escaped us. Most important, among the more delicate problems is to get into touch with the people that matter in the shipping world, people who are disposed to listen and discuss what we have to say. This is, of course, not surprising, since the shipping world knows little or nothing of our work; it is nevertheless disappointing just the same. Other industries have been more approachable.

On the other hand, what can we offer the shipbuilder? All discussion and suggestion on this problem has been made by the plastics chemist or plastics technologist and necessarily has been on very broad lines only and based on experience, again necessarily, obtained from other and very different industries. As a preliminary approach to the subject this is satisfactory. Indeed, there is no other method of approach. Dr. Caress's recent paper before the Institute of Engineers and Shipbuilders, which we noted in our January issue, was excellent from this point of view and, indeed, must have provided food for thought to the progressive Naval architect.

More than ever therefore, if we are to succeed in part or whole of our aims, it is necessary to get the shipbuilder's view of the problem, and it is as well to begin at the beginning. This being so, we have asked an old friend, Mr. A. C. Hardy, to

give us his views. We publish them on p. 52 of this issue. With an experience of nearly 20 years, he possesses not only a great knowledge of shipbuilding, but also an intimate understanding of the ways of the shipowner and shipbuilder and of the whole economic "make-up" of the industry. Perhaps of equal importance is his acquaintance with plastics, an acquaintance which has created an enthusiasm for them.

The chief value of his notes lies in the fact that they gave us a broad view of the shipping industry, its composition, the character of the personnel connected with it, and, in a subsidiary fashion, what he believes can be made in plastics. On the whole, he does not allow his enthusiasm for plastics to run away with the ideas, and for this we are grateful, for the over-enthusiastic "amateur" has proved rather a nuisance than otherwise to the plastics industry, which in later years has become far more careful of new ventures than it was.

Some of his suggestions are obviously amenable to plastics application. The organic glasses are eminently suitable for glazing and indeed have here and there been adopted, but we must also be prepared for serious competition from the new toughened glasses, in the production of which research is continuous and promising. Small boats made from laminated material by a process readily adaptable to mass production are already being made in London, and a jump to lifeboats does not seem too great. Hatches 40 ft. by 20 ft. are possible to-day, for large structures of nearly the same size have been made for patrol boat frames by the scarf-jointing of resin-impregnated wood. The design of a hatch is comparatively simple, so that there would be little difficulty in production. An advantage of the resin-impregnated hatch would probably be the elimination of the tarpaulin, since the hatch should be reasonably waterproof. The structure would also be rot-proof and there would be somewhat less tendency to warp. Doubtless a slight change in design would be necessary to hold down the hatch.

We are glad the author regards insulation as a "probable," and certainly if the plastics industry can produce a strong structure as well as a highly insulating structure, the days of cork, glass wool, wood wool, diatomaceous earth and slag wool will be numbered. Design will then take advantage of mechanical strength plus insulating properties.

Few discussions lay stress on the fire-proofing qualities of many plastic structures or on plywood bonded or impregnated with resins. We commend the note we publish on p. 68 in discussing the new book "Plywoods," to all shipbuilders.

The All-plywood Hostel

AFTER considerable research and examination of what has been done elsewhere in this country and abroad, a new war-time economy hostel has been designed by the Ministry of Works. Less wood is used in its construction than was used in a pre-war hut of the same size classed as a "non-timber" building.

This has been achieved by attention to design so as to economize timber in every way and by the increased use of plywood, especially of resin-bonded plywood. Walls, roof, doors and furniture fitments are all of plywood on a light timber frame. They are made in sections in the factory and the pre-fabricated parts are then transported to the site and erected in a few hours on a cement base previously laid down.

The hostel is, roughly, 72 ft. by 18 ft. 6 ins. by 7 ft. 2 ins. (height to the eaves), with cubicles for 24 agricultural or munition workers. Cubicles are arranged 12 on each side of a central corridor.

Walls and roof are made in standard sections 6 ft. wide, of 1½-in. square timber framing divided into a lattice by ⅜-in. thick slats faced both sides with ¼-in. plywood, bringing the overall thickness of the walls up to 2 ins. From the point of view of heating, it will be an extremely comfortable hut.

In this hostel walls and roof sections are faced on the exposed side with resin-

bonded ply. Ordinary dry-cemented ply may be used for the inner sides. As to strength, Ministry of Works tests have shown that ¼-in. resin-bonded plywood can be made to do the work of 1-in. or 1¼-in. solid timber.

It seems a pity that the resin-bonded wood is confined to exterior work. That itself is a compliment, but we look forward to its application within the building when, not first costs, but long life, resistance to insects, fungus and fire are also considered.

POTTERY, GLASS AND PLASTICS.—The sixth of the series of 12 papers on "The Post-War Home: Its Interior and Equipment" was given by Mr. James Hogan, Master of the Faculty of Royal Designers for Industry. His subject was "Pottery, Glass and Plastics."

It is perhaps, he began, due to the climatic conditions under which we live in this country that we are forced to spend so much of our lives indoors. This being so, we should be wise to furnish our homes and to surround ourselves with articles cheerful in colour, beautiful in design and of good taste. Mr. Hogan could have given no clearer indication of one of the means that make life happier.

It is difficult to prophesy, he said, what the economic conditions will be after the war, but the demand for articles made from pottery, glass and plastics will be great and mass-production methods may have to be employed. If, on the other hand, we have to depend more on home markets, then this may lead to a revival of handicraft in order to give employment to the largest number. Even if this country continues to manufacture by machinery, it should be realized that the machine is only a modern form of the first tool and that it should serve to produce a greater number of useful and beautiful articles at low price.

On the subject of design Mr. Hogan is quite clear. The first principle of a good design is honesty. Much of the pre-war striving to be "modern" was insincere and false. It was founded on a style, if it could be termed such, which had no roots. The constant demand for novelties, too, was the reason why much that was bad was produced, for it often led to attempts to imitate objects made in another material. Manufacturers should produce goods in a few patterns of good designs to sell at an economic price rather than produce a large variety involving high costs for moulds, to satisfy the demand for novelty.

When we consider the scope of plastic moulding, which is only in its infancy, it would be difficult to predict the limit which it may eventually reach. The impetus the industry has received through the war and the astonishing number of different materials which it has replaced, such as earthenware, glass, marbles, wood, iron and steel, are some indication of the wide range of articles for which it can be used. In fact it has been one of the great faults of the industry in the past that attempts have been made to disguise the material by imitating the appearance of others.

Being a modern invention, manufactured entirely by mechanized processes, it has no tradition of handicraft, so that it is essential for those designing plastics to think of their products as existing in their own right and to break away in their designs from any attempt to imitate other materials or hand-made methods of manufacture. The designer, therefore, is not restricted by tradition derived from the past, but is faced with a problem for which there is no precedent to guide him. When this has been solved successfully, it has resulted in such a perfect form as the modern telephone.

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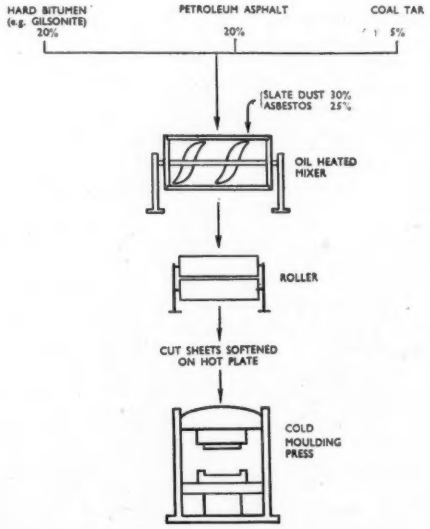
PLASTICS: *Their Origin and Formation*

I—BITUMEN PLASTICS

WE give these as the first of our series because they are in a separate category from the remaining types in so far as no chemical process is employed in making the moulding materials. They are relatively simple mechanical mixtures of bituminous compounds with certain fillers. The hot, soft mixture is pressed in a cold mould.

Bitumen plastics, while made from natural materials that have been in existence since the beginning of time, did not come into industrial use until the growth of the electrical industries; that is, the late 19th century. This occurred because all bituminous and, indeed, most organic compounds are good insulators of electricity. A solid, mouldable insulator became of supreme importance.

Principal Raw Materials	**Fillers**
Natural bitumens and asphalts. Residual petroleum asphalts. Coal tar and pitch.	Asbestos, slate and silica dust, cotton, flock, natural gums, lime, sulphur, etc.



Types of Mouldings: Overhead line insulators, terminal blocks, insulating bushes, panels, transmission parts, battery boxes and accumulator cases.

Mechanical Properties: Tensile Strength, 1,000 lb./sq. in.
Compressive Strength, 6,000 lb./sq. in. and over.

Physical Properties: Specific Gravity, 1.8-2.0. Softening Point, 100° C.
Dielectic Strength, 20,000 volts ($\frac{1}{8}$ in.)

Remarks: Cheap, black in colour although dark reds and greens are available. Attacked by oils, but possess good acid-resisting properties.

Balloons *for* Meteorological Research

The defects of rubber which we know so well on ground level become much more pronounced at high altitudes. The following notes give some indication of the efforts to overcome them by the adoption of cellulose-derived and synthetic films

BALLOONS employed for investigation of atmospheric conditions at high altitude have hitherto, with few exceptions, been made of natural rubber. In rare instances such balloons have ascended to heights of about 20 miles. Recently the Physical Institute of the Technical University, Stuttgart, began investigations on the behaviour of balloons in natural rubber and in transparent (synthetic resin) foils under conditions obtaining in the stratosphere. The ultimate aim of the research is to increase the altitude of ascent to 22 or 25 miles. Failure to do this with existing materials may be due to slight imperfections in the rubber-balloon envelope, but, nevertheless, even this explanation does not suffice to account for the bursting of rubber balloons at a remarkably constant height of 13.5-19 miles.

According to Piccard, strong U.V. radiation at greater heights makes the rubber brittle. Piccard protected his balloon by the use of an ultra-violet-absorbing pigment. Regner considers that a high ozonic concentration in the stratosphere may be responsible and, in point of fact, a maximum ozone concentration is found at a height of 13.5 miles.

Eisle considers that U.V. light and ozone together may be responsible, particularly when assisted by temperatures in the order of −50 to −60 degrees C. As the rubber envelope is nearly transparent in a stretched condition, absorption of sunlight and corresponding heating is small, so that the temperature of the balloon probably rarely rises above that of the atmosphere. Tests have shown that the resistance of rubber to conditions of this sort cannot be improved;* hence it was found necessary to try other materials, which must fulfil the following demands:—

(1) It must be mechanically homogeneous; (2) resistant to U.V. radiation; (3) resistant to attack by ascent; (4) mechanically resistant to the effects of intense cold (alternatively, it must be capable of being protected against mechanical deterioration at low temperatures); (5) if the materials cannot be "stretched" they must be capable of production in very thin foil form.

Experiments carried out by Regner and Johnson with balloons of transparent foil were not successful, as the envelopes burst into numerous small pieces on reaching ground level again.

Cuprophan foils remain elastic at temperatures as low as −45 degrees C., but at −55 degrees C. shatter like glass on the slightest contact. A remedy for this was found in the spraying upon the envelope of a black matt lacquer. It was determined that the thickness of the lacquer film was critical; its thickness should be such as to promote absorption of solar heat to maintain the temperature of the envelope at +10 to +20 degrees C. above that of the surrounding atmosphere.

* It is to be assumed that natural rubber is here referred to. Synthetic rubbers and rubberlike compounds are, in many cases, notably resistant to accelerated ageing by U.V. and by ozone.

Too great a thickness of film appeared to induce a tendency for the envelope to break at those points lying shadowed from the sun. The possibility of employing coloured foils was considered, but the spraying technique appears to be more advantageous. For example, different parts of the balloon can be sprayed in different colours or shades, whilst the matt surface obtained definitely refused to reflect, a factor of some importance.

Several years' work on the properties and high-altitude reactions on small balloons was necessary before a technique could be developed for the manufacture of larger balloons. The reason for this lies in the fact that the transparent foil envelopes cannot be distended as can those made in rubber. They must, therefore, be produced to finished size. Equally, it has not been found possible to make envelopes of spherical form; these must be composed of plane strips pasted together along straight lines on a plane table. Every effort was made to assure that, in the filled condition, they develop a roughly spherical form, first, in order that most favourable conditions of stress distribution can be obtained and, secondly, in order to maintain a minimum surface/volume ratio.

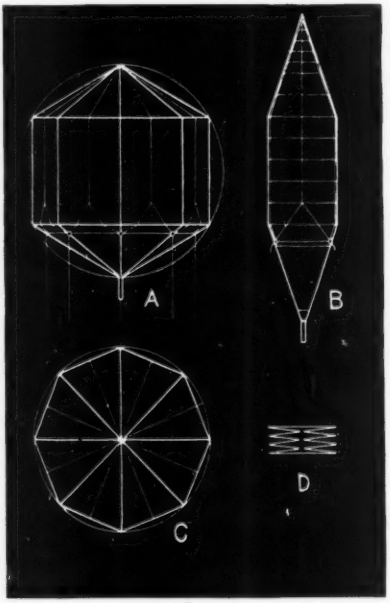


Fig. 1.—Construction of sounding balloons made of transparent foils. Left, in taut condition; right, folded. Design applied for balloons of 35 and 484 cubic yard gas volume.

In Fig. 1 a system of constructing such balloons of 35.3 cubic yds. and 484 cubic yds. capacity is illustrated. Among the foils experimented upon for the purpose were those of regenerated cellulose, cellulose acetate, cellulose nitrate and, finally, gelatine foils. It does not appear that foils of the more recently developed type, such as polyvinylchloride, were investigated. Although their great chemical stability would appear to recommend them, nitrate and gelatine foils were found unsuitable. The first could not be produced in the required dimensions, whilst the second is too readily affected by water.

For balloons designed to ascend to very great heights, very thin foils of high strength are necessary. For the purpose, a cellulose foil (Cuprophan) of a thickness 0.0065 mm. and weighing 10 grams per sq. metre, was used. The weight of this foil is less than that of rubber distended to its bursting point.

Some difficulties were experienced in building up balloons of this thin material. For balloons designed to ascend 22-25 miles into the atmosphere, minimum weight of the whole assembly, including operative, is essential. Actually, the measuring equipment carried weighed 700-1,000 grams; for heavier apparatus, the use of thicker foils might be found necessary. In every case balloons were inflated with hydrogen. Fortunately, gas lost by diffusion was found to be extremely low with Cuprophan foils, being 0.114 mg. per hr. per sq. cm.

For rubber, the corresponding loss was 0.18 mg. per hr. per sq. cm. Diffusion speed was found to be influenced by the moisture content of the foil. In the production of the balloons all danger of untoward mechanical damage had to be avoided; particularly were precautions taken to avoid operatives treading upon the foil.

To assist in the attainment of this end, the width of the plane surfaces was reduced with balloons of increasing volume in order that the strips could be laid on a pasting table not more than 2 yds. wide, joining being carried out with free arm movements from both sides of the table.

The equatorial section of the balloon of supporting bands was also provided to give increased strength longitudinally. The longitudinal stiffeners all met at the poles of the balloon and, these being points of greatest stress concentration, were capped with two layers of Cuprophan cemented together.

It is interesting to note that the flow direction of the material used for the stiffening discs was arranged at right angles. The filling tube was also constructed in Cuprophan and the point of insertion was strongly reinforced.

The finished balloons, still stretched on the pasting table, were next spread with a special cellulose lacquer giving a matt black finish and possessing good powers of adhesion for the Cuprophan. When,

Table 1.—Data of Registration Balloons.

Volume		Meridian section, No. of corners	Equatorial section, No. of corners	a (yard)	b (yard)	Weight		Surface, sq. m.	Weight of film		Service weight, kg./sq. m.
cubic m.	cubic yd.					lb.	kg.		lb.	kg.	
27	35.5	6	8	1.875	2.65	2.87	1.3	49	0.22	0.1	0.026
250	328	6	14	1.905	4.96	8.22	3.73	195	1.00	0.45	0.019
370	485	6	8	3.78	5.31	10.35	4.7	260	1.54	0.7	0.018

35.4 cubic yds. capacity was a regular octagon (Fig. 1), whilst that of the 484-cubic-yd. balloon was a 14-sided figure. In the case of the 1,300-cubic-yd.-capacity envelope, a 24-sided figure was used.

In the course of the research it was discovered that the mechanical properties of viscose and Cuprophan foils varied according to the direction in which they were measured. Thus, in both cases, strength along the direction of flow was greater than that measured across the direction of flow. A viscose strip of 0.3 mm. thickness, 15 mm. wide and clamped at points 100 mm. apart, gave a breaking strength of 3.96 kg. in direction of flow and 3.02 kg. at right angles to this direction. Heating of the foils increased the difference between these measurements. To compensate for lower strength across the direction of flow, balloons were provided with equatorial strengthening ribbons of a cellulose material (Vellohermeto), whilst a net of

finally, the correct thickness of lacquer was determined, heat absorption up to 25 per cent. was obtained.

An accompanying table gives technical data on some of the trial balloons. The surface weight of 0.018 kg. per sq. metre may possibly be reduced in the case of larger balloons. Atmospheric pressure at a height of 25 miles is approximately 2 mm. kg., and for the ascent a balloon of 36 metres diameter is required. Prior to the outbreak of war, envelopes of 2,600 to 3,900 cubic yds. were proposed for ascents up to 22 miles; the length of such balloons would probably have been about 27 yds. In all, 40 trial ascents were made; a few of these will be considered.

In Fig. 2 is a curve for the ascent of the 35-cubic-yd.-capacity balloons. These consisted of unsprayed transparent Cuprophan. Theoretically, these balloons should have reached an altitude of 11.3 miles, but descent took place after they had reached a height of 9.25 miles. The heights reached by these balloons in

numerous trials varied from 11.2-7.5 miles. Ascent was quite normal until the envelopes came into the temperature range of the lower stratosphere, which was encountered at various heights, according to general atmospheric conditions.

Cuprophan cooled down quickly until at the very low temperature reached it burst, whereupon hydrogen escaped and the envelope dropped. Speed of descent was slow or rapid, according to the locality in which bursting of the envelope occurred; similar results were obtained with the larger balloons of 484 cubic yds. capacity. Theoretically, height of ascent

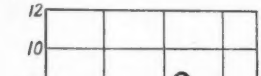


Fig. 2 (left).—Ascending curve of three different balloons of transparent foils, used in unsprayed condition, volume 35.4 cubic yards.

Fig. 3 (right).—Ascending curve of a balloon of transparent foils, sprayed with black lacquer.

of each was 16.6 miles; that is, descent took place from practically the same height as observed with the smaller balloons. They came down torn to pieces, destruction being greatest at the lower part of the envelope. The significance of this observation lies, of course, in the fact that the taut upper part tended to become somewhat warmed, whilst the lower part remained in shadow and, therefore, became cold. This fact was taken into consideration in developing a lacquering technique for the balloons, on the lower part of which the thickness of the lacquer film was fixed at one-third of that applied to the upper part; this was done in order to promote height absorption in the lower portion.

The apparent result of these measures was a high ascent of the larger balloons. With sprayed balloons of 35 cubic yds. capacity, seven trial ascents have been made. Only four balloons were found, however, and of these the lacquer films upon two were excessively thick, so that they attained heights of only 5-6.2 miles. Nevertheless, they were less damaged than the unsprayed balloons. From the other two only one barogram was obtained, the barograph in the other being destroyed during landing. The barogram is shown in Fig. 3 and the contrast presented to those reproduced in Fig. 2 should be noted. The maximum height obtained was 9.5 miles, speed of ascent being 362 ft./min. up to a height of 9.55 miles, with a period of 45 mins. during which the balloon glided in the air. After sunset lift was reduced as a result of decrease in temperature and the balloon assumed a more rapid descent. Unfortunately, beyond this point no further readings could be taken, due to damage to the instrument basket during landing.

The difference of 1.25 miles between theoretical height and that actually obtained may be attributed to hydrogen loss, together, possibly, with weight increase due to water absorption.

Telescopic observation was maintained upon all balloons during ascent and descent, and it was observed that the ascending speeds of all balloons was fairly constant and, assuming a maximum value of about 490 ft./min., balloons could be observed for 100-120 mins.

Obtained Results

From about 40 performed ascents only a few will be discussed in the following. Fig. 2 shows an ascent of 35-cubic-yd.-volume balloons which were not sprayed, but consisted only of transparent Cupro-

phan. The theoretical height of these balloons was 11.3 miles, but the descent took place after a height of about 9.25 miles had been reached. The average maximum height from numerous ascents was only 11.2 to 7.5 miles. The ascent was quite normal until the balloon came in the range of the low stratospherical temperature, which was encountered at various heights, according to the general atmospherical conditions. The Cuprophan cooled down quickly until it burst at the very low temperature, the hydrogen gas escaped and the descent followed. The descending speed was slower or quicker, according to which part of the balloon the burst occurred, either in the lower or upper part. The same occurred with the larger balloons of 484 cubic yds. volume, the theoretical height of which was 16.6 miles, but which reached generally only heights from 5.6 to 8.7 miles; i.e., the descent occurred at nearly the same height as with the smaller balloons. They came down absolutely torn into pieces; the greater destruction of the lower part was evident. Obviously, the taut filled part was somewhat warmed up, whereas the lower part remained cold. This fact was later on considered in the lacquering of the balloons, as the thickness of the film was reduced to one-third for the lower portion; therefore this had a greater heat absorption. The apparent result of these measures was a higher ascent of the bigger balloons. With sprayed balloons of 35 cubic yds. volume, in all seven ascents have been made, but only four balloons were found. Two of these balloons had a too thick lacquer film, so that they attained heights of only 5 to 6.25 miles, but they were less damaged than the unsprayed balloons. From the two others, only one barogram could be taken, as the barometer of the other had been destroyed after the landing. Fig. 3 shows the one obtained barogram, which is absolutely different from those reproduced in Fig. 2. The maximum attained height was 10.5 miles, the ascending speed was 362 ft./min. up to a height of 9.55 miles, and it glided for about 45 mins. in the air. When, after sunset, the lift was reduced through the reduced radiation, the balloon assumed a more rapid descent. The barogram could only be taken up to this moment, as the instrument basket was damaged in the landing. The still-existing difference of 1.25 miles between the theoretical height and the attained height can be explained by the hydrogen loss; a further factor may be the open filling end and a weight increase through water absorption. As the movement of all balloons was also observed by a telescope, it was seen that the ascending speed of all balloons was between 430 to 490 ft./min.; the balloons could be observed for about 100 to 120 mins.

Plastics Industries Technical Institute

This Institute, which began work in Los Angeles, California, last year, is publishing regularly a four-page digest of plastics development in the U.S.A. and abroad under the title of "Plastic Trends." These abstracts cover a wide range and deal with all subjects, including pure chemistry and physics of plastics, manufacture and plant for plastics, and applications of plastics.

In addition to this digest, the present issue contains random examples of research projects undertaken in the laboratories of the Plastics Institute and if readers express sufficient interest in this additional service it will be continued. For our part we welcome the suggestion. Since the Plastics Industries Technical Institute is probably the only institute in the world dealing solely with plastics problems, the research work it carries out will undoubtedly bear the mark of comprehensive and collective thought as compared with the rather incoherent work generally carried out.

Two examples of research have been selected. First, "Water Absorption of Resin Impregnated Oregon Pine," by R. S. Hawkins, and the second, "Volumetric Expansion of Plastics," by M. A. Azam. The first was carried out using phenolic resins soluble and insoluble in water. The raw materials for the second were the co-polymer polyvinyl chlorine-acetate, and polystyrene.

D

A model of a centrifugal pump. The feed end is in the rear.

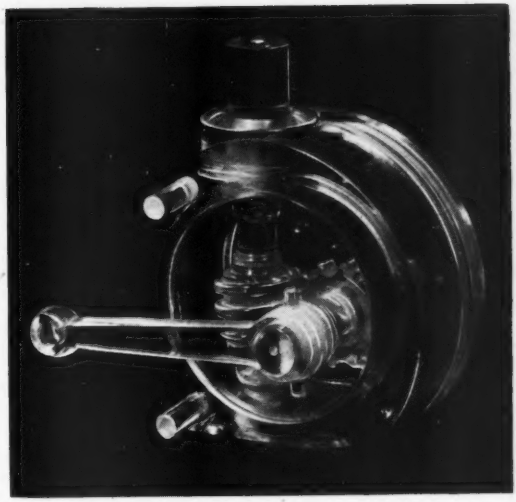
Transparent cast-resins and other plastics create a new weapon for modern industry

TRANSPARENT MODELS *for the* ENGINEER

IT is exciting to watch growth, whether it is the growth of a newt, of a living plant, or of an industry. During the past few years we have watched a tiny section of the plastics industry that may claim to be unique—unique in the sense that no other material of construction in the world, not even glass, can quite usurp its place. Its development in those few years has been as fascinating as it has already proved industrially important.

Of all walks in mechanical and scientific industrial life, we believe there is only one in which the worker can watch with his own eyes the direct course of his experiments, of action and reaction. The chemist in the laboratory has fashioned his tubes and flasks of transparent glass. He can, for example, watch the behaviour of a continuous distillation, feeding in a liquid to the still at the same rate as the

Connecting rod and lubricated ball-bearing system.



Worm-gear, actuating gear and casing of transparent cast resin.

liquid is distilled away and condensed.

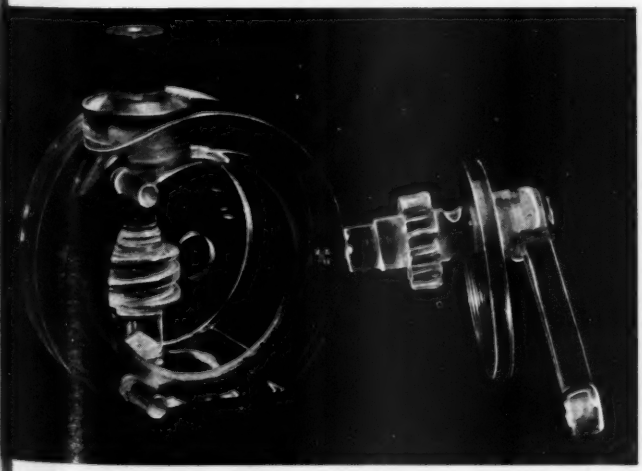
Not so the engineer, whose very models have always been opaque. No engineer has ever seen the inside of a pump or turbine while it is working, although he has probably subconsciously wanted to. He knows by experience and reasoning what should and does happen, but he has never seen it.

This note is not an indication that he will ever see within his pumps or turbines. Prophesy of this kind does not get us very far.

What has happened is that he can at least now construct transparent models for research work or alternatively for the highly important function of teaching, and need no longer rely on blue prints for this purpose.

We have already given some examples of such models, all of which have been machined from cast phenolic resins. Yet another concern, Runcolite, Ltd., has entered the field. The accompanying photographs show some of the very remarkable work that has been done. The worm-gear and the connecting-rod with its lubricating system are among the best of this type we have yet seen.

As for the centrifugal pump, this was made by Mr. Ballard, of Runcolite, Ltd., at our request. Doubtless such a model should prove of value in carrying out research work on the pumping of sludges and similar fluids that are conveyed with difficulty.



A dismantled view of the above gear.

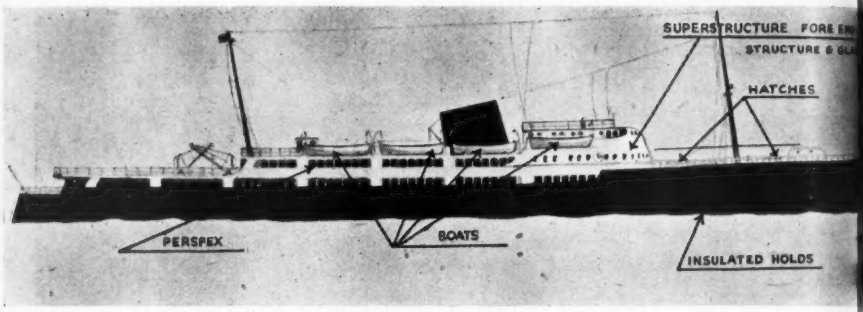


Fig. 1.—Modern passenger packet showing possible plastic applications. She is "glazed in" for over 50 per cent. of her length.

Plastics Can Help The Shipbuilding Industry

THE vast changes now going on around us are unlikely to pass without leaving their mark on the ship. Man's foremost instrument of transport, necessarily, though not always wisely, the most traditional of all, must adapt itself.

While we cannot forecast the full nature of changes to come, we must try to anticipate them, and now is the time to plan for them.

Light metals, improved navigational devices, new arrangements for propulsion —these must all find a place in the aeroplane-affected, fast hull of the future.

So, too, must plastics; for therein lies a completely new industry. With its effect upon forms of construction we are not very much concerned here. It is proposed, rather, to indulge in a sort of deck clearing which will put before this growing and important industry some indication of the size of the marine market, the requirements of shipbuilders and shipowners, and the way in which plastics must approach ships, with a view to

Fig. 2.—Hatch covers (40 ft. x 20 ft.) on a tramp. Each is covered with a tarpaulin held securely in place.

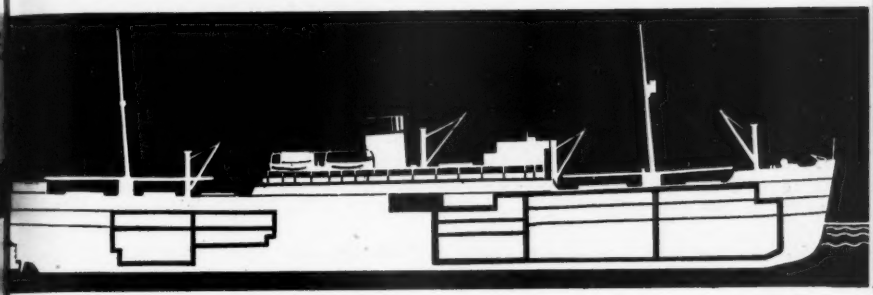


Fig. 3.—Over 500 ft. long, this insulated ship carries half-a-million cubic ft. of cargo. The insulated space (claimed as a plastic possible) is clearly delineated.

An Introductory Survey of Possibilities and Requirements in one of the Greatest of Industries

By
A. C. HARDY,
B.Sc., A.M.Inst.N.A.

securing maximum use of undeniably good and important products.

There is no doubt that the war will affect the plastics industry tremendously. World-wide hostilities, with the enormous inroads they are making on the world's merchant fleet, will result not only in enormous post-war reconstruction but also in an entirely different set of circumstances.

It is unlikely that we shall pick up the broken threads of shipbuilding where we left them in September, 1939, either as to type of ship or method of construction. This alone means that new ideas, new material, will receive attention to an extent which could not conceivably have been the case had normal evolutionary processes gone on.

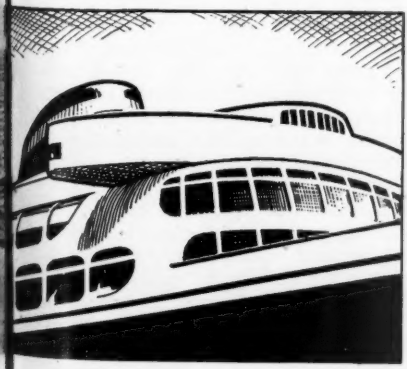


Fig. 4.—Stream-lined fore-end to the superstructure of an ultra-modern passenger carrier. Note the easy curved lines.

It is best, therefore, to consider the ship of the future, in the attached Family Tree 1. There is nothing new in this tree. The writer employed it first in a talk which he gave to the Oil Industries Club last year on the Ship of the Future. He also used it in an article in a contemporary, "Light Metals," when the probable future of this equally new, and to some extent complementary, development was reviewed.

Briefly the ship of the future is affected by unpredictable things, such as economics, the eventual settlement of world affairs, and the rapidity with which skilled labour to operate the developments shown under predictable things can be adapted to shipyard practice. Conversely this speed is also affected by the way in which shipyard practice can re-orientate

itself to the use of new labour and methods of operation.

The Hastening of Change

We can predict with some degree of certainty that aircraft development will affect the shape and speed of ships. It was doing so before the war. The period of hostilities will step up this process.

As is shown by Fig. 1, a design likely to be seen on post-war trade routes, curves and glass are dominant features.

We do know that the employment of light metals, which had begun to obtain a foothold in the shipbuilding industry just prior to the war, is likely to move very swiftly after the war. Some people concede that the speed will be accelerated because of the amount of light metal available, its easy production and adaptation, and a certain dislocation in the output of the older and heavier materials of construction. With light metals, and indeed with conventional metals, welding is going to play a much greater part. Already in America we are seeing all-welded tankers of large carrying capacity, whilst welding, having crept into the superstructure of the hull in recent years, is now "creeping" downwards and upwards.

This is all-important background. None of these developments should be taken in any way as potentially rivalling the increasing use of plastics . . . the growth of a technique which had already started in pre-war years, chiefly in small interior fittings in the cabins on ships.

Before we arrive at any conclusion as to where plastics will eventually arrive in shipbuilding of the future, it is of interest to the industry to make a few trite remarks about shipbuilding and shipowning.

Shipowners in the main are a conservative class of beings. This is inherent in their work. They cannot afford to take risks, either practical or economical, in the highly complicated and technical business of ship-running and operation.

They are, nevertheless, in the main, individualists . . . up to a point. That point is the design and construction of their ships. Here, they are very inclined to place themselves almost entirely in the hands of the shipbuilder. He, in turn, particularly in this country, is cautious, deliberate rather than daring. He may not always be right in his choice, say, of speed . . . on the other hand "he is never wrong." While this is in the main true of British shipbuilders, and is true to a decreasing extent as time goes on, it does, nevertheless, give a fairly accurate picture of the mentality of the industrialists to whom plastics must appeal.

The plastics technologist will gain nothing by over-enthusiasm, nothing by insisting that shipping must use his products because they are so obvious, nothing by swamping the shipbuilder or shipowner with chemistry. They are so little interested in the chemistry of plastics, and so much interested in the results, that chemical analysis will tend, if anything, to destroy confidence.

The Character of the Industry

Both the shipbuilding and shipping industries are highly specialized. There are all kinds of shipowners—the tramp owner, the cargo-liner owner—in fact, almost as many owners as you can find ship types in Family Tree 2, which shows the kind of ships able to use plastics to a major or minor degree. Very many of these types are catered for by builders who, throughout their careers as firms, have specialized in this kind of construction. Thus, an organization which has spent its life building 9,000-ton tramps, or 5,500-tonners or coasters, is in a different category from the man who always specializes in cross-Channel vessels. Neither of these would presume to tackle a large refrigerator ship with upwards of half a million cubic feet of insulated space. Yet such a builder would be well qualified to turn out a 30,000-ton 24-knot liner.

This is rather important, because any approach to the shipbuilding industry by the plastician cannot be a universal one. It must be well-graded, with due cognizance given to the way in which the products in Tree 3 fit into the requirements of the type in Tree 2.

There is another aspect of the situation which the plastician will do well to study, and that is the vexed question of labour. The demarcation of labour in shipyard practice is something which has to be seen to be believed. The introduction of welding alone has brought its difficulties, for, in addition to completely turning upside down generally accepted shipyard practice, as regards the sequence and the method of hull construction, it has brought in its train an entirely new class of technician. The welder, in short, is the product of the last decade. The light metal worker might well be another specialist, and he will probably be joined in post-war years by the shipyard plastician, i.e., the man skilled in the working, erection and maintenance of plastic products. He must, however, fit in very carefully to the accepted scheme of things, a problem which may best be solved by taking over and " converting " existing sources of labour rather than by introducing completely new blood.

Then, too, there is another vitally important body to be considered. That is the classification society. As is probably well known, all ships are built to " class," as it is called, with some particular society. This must be done in order that proper insurance may be obtained from underwriters. Lloyds is usually considered the highest from the point of view of its requirements. The British Corporation is another, whilst each of the principal shipping nations of the world usually has its own national society.

These bodies frame the rules to which ships must be built, covering methods of construction, scantlings, materials of construction, etc. Therefore, before the plastician can hope to interest the shipbuilder or shipowner, he should first very carefully make his peace or his terms with the classification societies. They will require tests, tensile, compressive, etc., according to the type of plastic. Armed with such certificates of competency, plastics will automatically have taken their first fence on the road to success, a road which leads to one of the richest markets in the world, whose merchant marine totalled at the outbreak of war nearly 67,000,000 gross tons of shipping and nearly 30,000 individual vessels. How much of these will remain on the

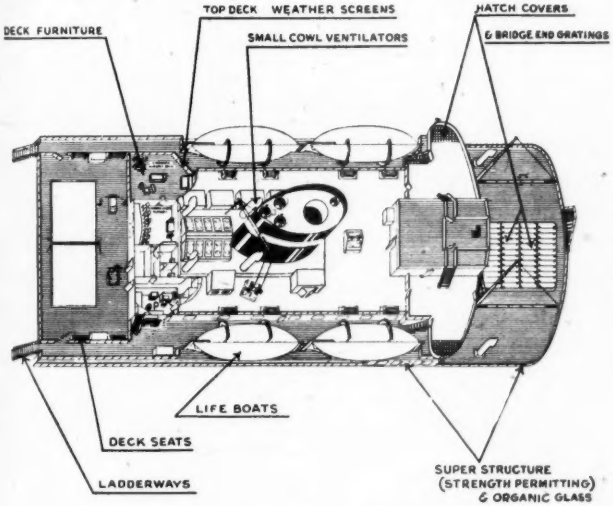
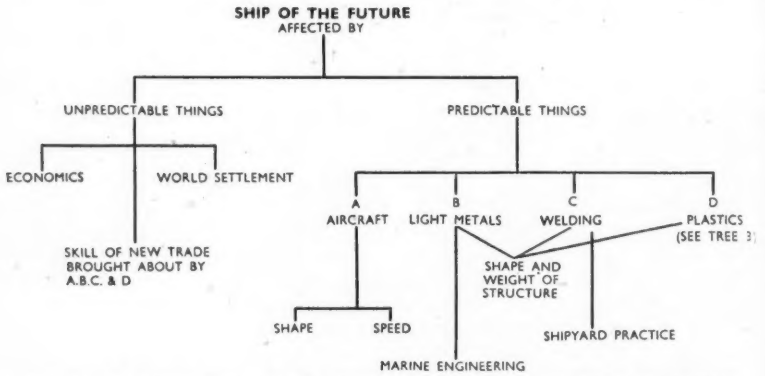


Fig. 5.—Some indications where plastics can enter into the building of a modern passenger motorship.

conclusion of peace it would be idle to guess. Nor are we concerned with them, from a plastician's point of view.

Certain it is that very large replacements will have to take place, and there is no reason why these replacements should not, in some way or another, have some representation of the plastic industry on board.

As for future peace years, it is interesting to note that, in 1938, world shipyards launched over 3,000,000 gross tons of shipping of 100 gross tons and upwards, in nearly 1,200 hulls. The British figure on this occasion amounted to just over



Tree 1.—The factors likely to affect the ship of to-morrow. It indicates the position occupied by plastics whose detailed applications are explained elsewhere.

1,000,000, all of which, in a post-war year, would be potential users of plastics, in one form or another. The war will finish with the world's shipbuilding facilities greatly extended. America alone is stated to be aiming at a 5,000,000 gross ton per annum figure already, and this may well be exceeded.

For even to-day it is modern methods of construction, light metals and, perhaps to some extent, though a limited one, plastics, which are making possible the ready construction of merchant shipping.

Rapid shipbuilding is, to a great extent, a matter of planned method. However carefully the method is planned, this, too, is governed by the type of material employed. Light metals, or even conventional metals, in association with welding, and, I feel certain, plastics, would inevitably cut down time of construction, because of the "handleability." Before this can be done, a technique for this handleability and workability must be built up.

The problem in this case is somewhat different from light metals, which at least bear some similarity to conventional material. This is important, if only from a psychological point of view.

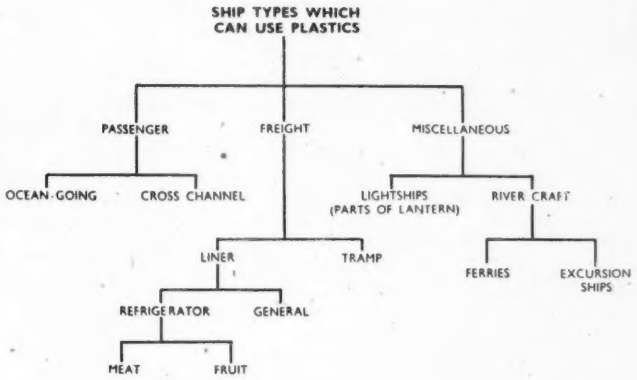
So far I have painted a picture—and, I think, a rosy one—of a big potential market. This has been done without any examination as to what has gone before in the way of the plastic equipment of ships, or without any guide as to what the shipowner and shipbuilder would like plastics to do. The first of many questions which will be asked is, why use plastics in preference to other material? Then they will want to know if they are lighter than steel? Are they lighter than aluminium alloy?

Can they be married structurally to light metals or to steel?

What is their strength compared with other materials of construction?

Are they wave-proof, wind-proof, corrosion-proof?

Are they likely to deteriorate in structures at the point of their "fastenings"



Tree 2.—This does not show all types but those most likely to employ plastics. It provides the plastics technologist with an idea of their relationship.

to the essential strength hull of the ship?

Are they easily repairable in the sense that a patch can be welded on a steel plate?

What is their reaction to violent changes of heat or cold?

Can they be made fire-resistant? (This alone would be a vital factor in their favour.)

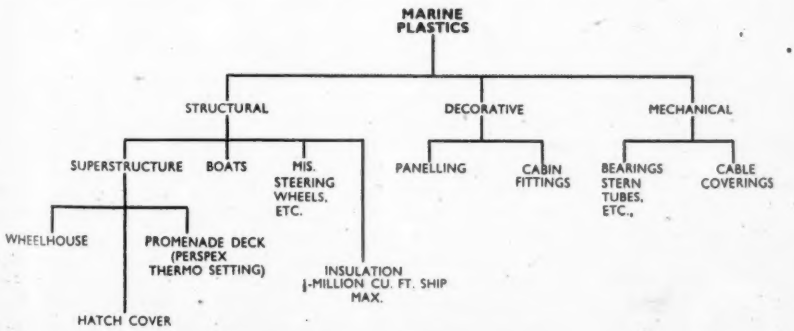
Will they take paint readily. . . . In short, what do we know about them from the shipbuilding point of view? Fig. 2, though applying specifically to hatch covers, repays study in the light of these questions.

The answer appears to be very little, because, as I have said earlier in this article, with the exception of certain cabin fittings in pre-war ships, but little seems to have been done.

One characteristic does seem to be of prime importance for shipbuilding plastics, i.e., that they can be moulded into almost any shape desired. But then, from a point of view of practical engineering economics, is it possible to mould, say, one or two large "castings," and then adapt the machinery for other purposes?

These, possibly, are all points which the plastics technologist himself will attend to, when and if he is certain that a big market lies before him.

Information of recent date, available to the shipbuilder, is rather rare. The literature of plastics is good, but still not sufficiently specialized. The North East



Tree 3.—This sets forth the main categories into which the marine applications of plastics presumably fall.

Coast Institution of Engineers and Shipbuilders, among the most live body of its kind in the engineering and shipbuilding industry, recently had the benefit of a paper entitled "Plastics and Engineering," by Dr. A. Caress, of I.C.I., Ltd.; but here, frankly, from a practical shipbuilding, and still less from a practical shipowning, point of view, there is but little to be gained, as the paper is, in the main, a chemical exposition. There is, however, comfort in his statement to the effect that plastics will approach considerably nearer to metals in hardness, elasticity, toughness and strength.

Dr. Caress also gives us an interesting example of the way in which weight can be saved in a turbo-electric ship by citing the case of the German "Scharnhorst," in which there was a considerable reduction in weight by the use of extruded plastic insulation in place of the heaviest lead-covered cable previously employed. This certainly appealed, if only for the fact that it indicates the possibility of a considerable reduction of weight per h.p. in turbo-electric or Diesel-electric propulsion equipment in ships of the future.

Importance of Technical Publicity

In a recent issue of the "Shipping World" Dr. V. E. Yarsley contributes a most interesting article entitled "Plastics in Ship Construction and Equipment." Here he undoubtedly tells shipping people much of what they are anxious to know, and his article may be regarded as one of the most important attempts by the plastician to "make friends with" the naval architect. The way in which he explains his thermoplastic and thermosetting plastic is both simple and helpful. The information he gives concerning the vinyl, Styrene or methacrylate polymers is of interest from the superstructure point of view, since these include the glass-like plastics well known to industry, among which may be listed Perspex. The superstructure question is again touched on in his statement that the wide range of aircraft units now manufactured by pulling plastic sheets round relatively simple formers will certainly find wide application in the post-war world. Can plastics supply a structure like that shown in Fig. 3?

He makes an important point when he suggests that it has been the misfortune of plastics that, in many instances, they have found favour in industries only in place of conventional material, and they have in consequence been regarded by many as substitutes, whereas in actual fact they are the modern materials of construction.

Shipbuilders will be interested to hear that plastics exist with the strength of metal, the lightness of wood, the transparency and brilliance of glass, in a tough material which will almost float on water.

Use of Insulated Materials

What does seem to be of considerable immediate importance is the fact that plastics may be of use in insulated hulls. The average fruit-carrying ship has upwards of 200,000 cubic ft. of insulated space. The average meat carrier has nearly half a million cubic ft. These are all in holds and 'tween decks insulated throughout, through which cool air is passed by fans, or in which, in certain cases, cooled brine is passed by grids at the top of the holds. In this connection, Isoflex, a new plastic lightweight thermal insulation, seems interesting, and Fig. 4 is worth study. It outlines the insulated area in a large, modern meat carrier.

We are told, for example, that the weight of Isoflex is about a tenth that of slab cork. It is corrosion- and rot-proof and is quite inert to salt water. It does not disintegrate as a result of vibration and is non-inflammable. Most of these characteristics, especially vibration and lightness of weight, appeal tremendously to the owner of the fruit ship. These fast vessels have speeds of upwards of 18 knots and will undoubtedly be built in large quantities in post-war years.

Another interesting outlet for plastics appears to be in hatches or, rather, hatch covers (see Fig. 2). We are told that hatches and fittings, which are strong yet light, and which will resist the ravages of sea water, should certainly

repay the extra cost of the plastics, as compared with wood or steel. Lightness is undoubtedly a big advantage, but the shipbuilder naturally asks immediately what distortion, if any, will take place? How will the plastics stand up to being thrown violently from the top of the hatch to the deck? How watertight can the hatch be made? Will it shrink? These and other practical matters will all have to be attended to. It does seem, however, that plastics may go a long way to solving the age-old problem of how to make the hatch watertight.

Structural and Decorative Plastics

All the above seem to be eminently practical suggestions. If one allows one's imagination play a little bit, Family Tree 3 can result, and we see that the possible marine uses of plastics are three: Structural, decorative and mechanical. The decorative uses are too well known to emphasize here. Plastics are undoubtedly greatly appreciated these days by the interior decorator and will be used to an increasing extent in post-war ships. Their lightness, simplicity, essential cleanliness, in addition to the endless decorative possibilities that they give, all warmly recommend them. The most attractive possibilities for large-scale manufacture seem to be structural. I have already mentioned the question of superstructure. To this we may add such important parts of the ship as the wheelhouse on the navigating bridge, promenade decks, where curved and strong glazing with organic glasses is worthy of consideration. A ship-of-the-future profile is reproduced in Fig. 3, while Fig. 4 shows a boat deck of a recent passenger-carrying motor liner.

Then, too, there comes the question of lifeboats. If plastics are to be used here, then they will find themselves unquestionably in competition with light metals, as may well also be the case in certain parts of the superstructure. It will be interesting, incidentally, to have opinion as to the practicability of using plastics for, say, a modern streamlined funnel, which does little else, other than serving a decorative purpose, than hold the tops of silencers from the main oil engines.

Structurally, plastics can be used for a number of miscellaneous duties, such as steering wheels, steering pedestals, and it may even be, perhaps, that they might take the place of the massive brass castings of engine-room telegraphs, although it might be a heresy from a marine point of view to suggest it.

Then there is the question of insulation, which I have touched on already. This would seem to be an immediate post-war field and, indeed, an immediate field of to-day, provided the material is available. Insulated ships will increase numerically enormously in post-war years.

Finally, we come to the mechanical side. Frankly, there is far less that plastics can do in the engine-room of to-morrow than light metals. One does think in this case of the possibility of bearings and, perhaps, of sterntube glands, although the use here all depends upon the ability of the plastician to produce the materials to stand up to the severe conditions of operation to be found in those parts of the mechanism.

Cable coverings are apparently already a practical possibility. Plastic "castings" might be employed as seatings for some of the lighter auxiliaries. Here, too, they must be able to stand up against severe vibration and heavy knocks.

Conclusions

To sum up, then, it may be said that shipbuilding and marine engineering will welcome the plastics technologist, but they will not seek him, although their minds are now well attuned to new ideas. The benefits he will confer upon them will be many, but they will be able to get along quite well without him. It is, rather, for the plastics industry itself to decide and to make the appeal.

Having done this, if he prepares his ground carefully, logically, without any undue enthusiasm and making the right friends as he goes along, he will find in post-war years a market of enormous potentialities which will more than repay the research work.

PLASTIC COATING for

The production of instrument or indicator dials has so increased with the general adoption of scientific methods in industry, that new resins and methods of applying them are being—

A NEW method of making instrument dials in such a way that they are said to remain white indefinitely has been developed by the Meter Division of the Westinghouse Electric and Manufacturing Co. at its plant in Newark, N.J. These dials are coated with a recently developed white plastic (the nature of which is not revealed), which is sprayed on a metal backing, much as paint might be sprayed. Immediately after spraying, the coating is surface hardened by quick heating and is then completely dried in an electric oven under automatic control.

Announcements state that the lacquered dials previously used turned brown after 10 hours in dry air at 317 degrees F., and an atmosphere saturated with sulphur dioxide caused yellow splotches after 100 hours. Identical tests

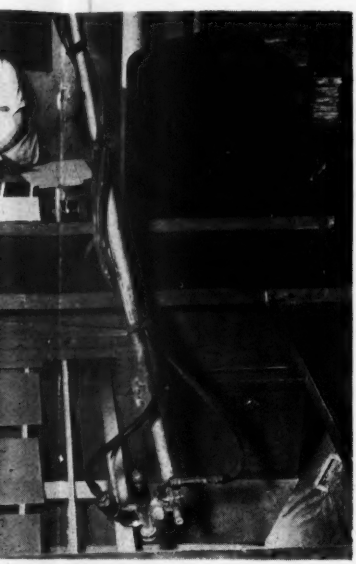
Fig. 1 (right).—The two oscillating guns in the foreground automatically spray the plastic coating on carefully prepared metal sheets as the latter pass—

Fig. 2 (below).—Special engraving press which prints the scales (and registry marks) on the plastic-coated metal.

Fig. 3 (above).—Punchin
registry ma

for INSTRUMENT DIALS

—constantly evolved, in order to obtain the best results. Whilst high-class synthetic resins for stoving are far from new to this country, the American methods of application are interesting



—below the guns on a conveyor which then carries them through a heating tunnel where the surface of the coating is hardened quickly.

are said to leave the new plastic-coated dials unchanged. This test gives a good indication of the film surface under normal working conditions.

Spraying is done in a room which is designed to exclude dust and is fed with filtered air under a slight pressure. Precautions against dust in the heating tunnel for surface hardening are also taken. After drying, dials are lithographed in a special machine in an air-conditioned room. Printing is difficult, as the hard plastic surface is completely impervious to ink. Lithographing includes the application of registry marks so placed that holes subsequently punched in the plates in a stamping press insure registry when the dials are blanked from the sheet subsequently.

Fig. 4 (below). —Testing of dials for discoloration at controlled temperature and humidity.

e).—Punching holes at the registry marks.

PLASTIC SHEET and FILM MATERIALS

The author completes and summarizes his discussions on the types of plastic sheet used as wrapping

By
E. E. HALLS

(Continued from page 13)

THE papers are inert and stable if so-called " acid free," viz., they must be free from injurious chemicals representative of those used in their manufacture, or reaction products of them. If neutral to litmus paper when tested by placing wet litmus paper on a sample and pressing between glass plates for ten minutes, they can be regarded as sufficiently free from acid or alkali, and the pulp from which produced to have been washed enough to remove chemicals. Otherwise they may embrittle with age, or even tend to corrode or stain metal work, applied finishes, or to affect colours deleteriously. Neutral papers withstand temperatures up to 100-110 degrees C. without loss of strength.

They lose a little strength under damp conditions and much in very moist atmospheres. Similar remarks apply to treated papers. Waxes tend to soften between 50 and 65 degrees C., and bitumens between 60 and 90 degrees C., but little evidence of flow occurs up to 100 degrees C. Loss of strength under moist conditions is not so marked. The varnished papers and fabrics must be fully cured, otherwise they develop rancidity and corrode certain metals, particularly copper containing alloys such as brass and nickel silver. They rapidly lose strength if exposed to temperatures above 60 degrees

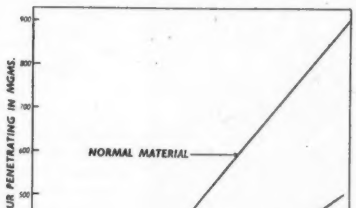


Fig. 11.— Moisture permeabilities of 0.002 cellulose acetate film, normal and waxed.

C. Rubber films should be hot vulcanized products, free from waxy substitutes or softeners and very low in free sulphur content. A reasonable life can then be expected.

As for the plastics, they may all be regarded as inert and non-corrosive. The cellulose acetates respond dimensionally to humidity and temperature fluctuations. Table 13 summarizes some results recorded from artificial ageing tests, and compares the three types of plastic film from this angle. It will be seen that the proofed regenerated cellulose is inferior to cellulose acetate, but that Pliofilm surpasses it in this direction. However, Pliofilm, although keeping satisfactorily under normal storage conditions for long periods, tends to lose strength under circumstances of extreme severity. This is shown by the records in Table 14, but in fairness to the material it is stressed that the extended tests are rather severe. The changes that occur in cellulose

Table 13.—Dimensional Changes of Plastic Wrapping Films under Accelerated Ageing Conditions.

Test No. and Conditions	Plastic Film 0.001 in. Thickness		
	Cellulose Acetate	Moisture-proof Regenerated Cellulose	Pliofilm
A. Dry heat at 60°C. for two days	Contraction 1.0%	Contraction 3.0%	Unchanged
B. Water immersion at 20°C. for one day ..	Expansion 0.5%	Contraction 0.5%	Unchanged
C. Specimen B, reconditioned at 75% humidity for one day	Unchanged	Contraction 5.0%	Unchanged

Note.—Before the tests all specimens were conditioned at 75% humidity (20/25°C.) for 24 hours.

acetate under similar test conditions are smaller and, in fact, negligible, as can be seen from selected data presented in Table 15.

It is to be noted, therefore, that the plastics, although stable and inert for perhaps the majority of applications, have their limitations. The latter are fairly well defined and thus successful usage of the plastics in specific applications can be foretold. All the plastics dealt with are odourless, hygienic and safe for application to foodstuffs and medical supplies.

This article has concerned itself largely with the quality of moisture-proofness, with particular reference to general wrappings. One fact more calls for reference, the role of moisture-proofness in relation to what may be described as " open " packs and to fully sealed contents. Dealing with the first of these groups, the need for a moisture impermeable membrane* that is merely folded around an article, and perhaps held in position by suitable adhesive, thus leaving relatively open seams, folds or overlaps, is sometimes thought to be a moot point. This outlook is considered to be wrong; the moisture-proof membrane still has a function to fulfil, and achieves this purpose well. Such a wrapping primarily encloses the article, prevents free contact with the atmosphere, and obviates any possibility of free movement of air around the article in such a way that it could promote gradual but continuous deterioration as by " drying-out." The membrane, too, takes care of a sudden change of atmosphere, either towards excessive dampness or greater dryness, and delays the corresponding change (to wetter or drier) within the package. It similarly takes care of condensation, and thus gives the contents a better opportunity to withstand fluctuating exposure conditions without marked change towards deterioration. Further, there are instances where protection against intermittent high humidities or moisture condensation is the primary object, e.g., wrapping of unprotected steel articles (knives, razor blades, tools) or preservation of electro-plated ware, e.g., chromium or polished nickel plate. True, complete sealing is ideal in other instances, e.g., biscuits and cereals for retention of crispness. In such cases a complete seal of cut edges and at folds is a specific advantage. Moreover, very heavily waxed cartons, wax sealed, or lighter card boxes wrapped in one of the moisture-proof materials, are used in applications of this class. In contrast,

Table 14.—Rate of Deterioration of Pliofilm shown by Bursting Strength Test Values taken at intervals of Artificial Ageing Tests.

Test	Period of Exposure	Bursting Strength Value lb. sq. in.		
		min.	max.	mean
As received or after normal storage for 2 years	—	7.0	11.0	9.1
Exposure to dry heat at 60°C. ..	42 days	4.3	6.2	5.5
Exposure to dry heat at 60°C. ..	140 days	Too brittle for test		
Immersion in water at 25°C.	42 days	4.8	6.2	5.3
Immersion in water at 25°C.	140 days	2.8	4.0	3.5
Exposure to hot and cold humidity	42 days	4.8	7.2	6.0
Exposure to hot and cold humidity	140 days	2.0	4.0	3.5

there are cases where complete sealing may cause spoilage because temperature fluctuation results in increase in humidity from the contents themselves inside the package, and this may result in mould growth, rancidity, " sweating," or other form of depreciation. A membrane material relatively good with respect to moisture impermeability often proves the correct wrapping in this case, providing protection against average conditions and safeguarding infrequent or intermittent circumstances where the high internal humidity, that would cause spoilage with a hermetically sealed package, is given an opportunity to breathe outwards.

The subject of adhesives and cements is outside the present scope, but it is stressed that when they are employed they should at least afford equal moisture-proofing properties to the membrane itself. The test method used for assessing the moisture permeability values of membrane materials can be readily modified for tests upon adhesives.

The purpose of this article has been to present a number of facts in as lucid a manner as possible rather than to launch off into the realm of " packing." It is not within its scope, therefore, to make recommendations, but, in concluding, it will, perhaps, not be considered out of place to mention specifically the plastics. For general wrappings, the plastics industry has commercialized three materials, viz., cellulose acetate, moisture-proofed regenerated celluloses, and the Pliofilm. They fully meet many requirements, chief of which are cost, range of thickness, variety of colours, manipulability, attractiveness, and from them the qualities of moisture-proofness and stability can be secured. Further advances are required and will assuredly come; already superficial coatings for cellulose acetate have been explored and the improvement of moisture impermeability achieved by wax treatment is shown by the curves in Fig. No. 11. Materials of modified composition or of entirely new type may quite conceivably be evolved in the not too distant future.

Table 15.—Rate of Deterioration of Cellulose Acetate Films shown by Bursting Strength Values taken at intervals of Artificial Ageing Tests.

Test	Period of exposure in days	Bursting strength value, lb./sq. in.		
		Film thickness—inches		
		0.0012	0.0020	0.0070
As received or after storage for 2 years ..		20	51	123
Exposure to dry heat at 60°C.	42	21	47	116
Exposure to dry heat at 60°C.	140	20	50	121
Immersion in water at 25°C.	42	22	48	86
Immersion in water at 25°C.	140	25	45	83
Exposure to hot and cold humidity	42	23	50	116
Exposure to hot and cold humidity	140	23	49	109

Note.—All samples cockled or crinkled on humidity test.

Military Requirements of Transparent Plastics

In a recent issue of the " Journal of Aero Science " (Vol. 9, December, 1941), Dr. Bartoe states that for best optical properties, transparent plastics must be used in such a way that all optical paths through the material are perpendicular to surfaces. As angle of incidence increases, reflection losses at both surfaces increase. Light transmission is reduced 45 per cent for angle of incidence of 75 degrees. Highly localized surface stress concentrations will cause crazing of all transparent plastics, especially when they are exposed to weather. Commercial acrylics are not appreciably embrittled by temperatures as low as −75 degrees F.

World's Industry Employs Plastics

GENERAL ENGINEERING

Roll-neck bearings of plastics feature a separation of the radial bearing, supporting the actual load from the neck-bearing carrying the axial thrust. Hitherto, the neck of the usual bronze-bearings had been copied for the plastic bearings. The disadvantage, however, was that the neck bearing had to be exchanged more frequently than the plain bearing. An arrangement of the collar or neck, as a separate piece fitting into dovetails, proved unsuitable, owing to the high notch-sensitivity of the plastic material. Study showed (H. P. Lemm, "Stahl und Eisen," 61,1941, p. 516; also "VDI Zeitschrift," 85, 1942, No. 34) that heating of the unit occurred in the majority of cases more or less through the neck-bearings. Various reasons may be responsible: insufficient lubrication and insufficient cooling are the chief. This is not easily cured, if no water spray is to be allowed on the roll surface, a fact of importance in the rolling of non-ferrous materials. There is also the possibility that scale from the roll may foul the neck, and this, of course, would cause rapid heating up, although it may perhaps be prevented by a simple cover over the bearing. Another means, now suggested, is to avoid the neck bearing, and using a radial thrust face just at the free end of the roll shaft. A relatively small ring of plastic is used, but, in spite of its small width, has greater durability than the usual neck bearing extending over only about 120 degrees. The wear of this new axial bearing is adjusted by means of a "bridge," whilst it can be well protected against dirt, water and lubricant. It is probably a step in the development of the fully enclosed plastic roll-bearing. **Phenolic-resin bearings** have been tested by Heidebroek to a maximum specific pressure of 750 lb./sq. in. Bearing temperatures increased from 30 to 35 degrees C. at sliding speeds of 60 ft./min., to the following temperatures at 600 ft./min. (specific pressures given in brackets):—56 degrees (750); 48 (450); 45 (275). **Uniform designations for resins** were introduced in Germany as from October 1, 1941. Thus a material S 1449 means a black (49) phenolic-resin mass (1) with about 40 per cent. resin content (4), of the type S (wood flour filler). The following numerical system is applied:—masses: straight phenolic resin (1); phenolic resin free of ammonium salts (2); phenolic-resin without smell (3); straight cresol resin (4); cresol resin free of ammonium salts (5). Approximate resin contents are designated thus:—35 per cent. (3); 40 per cent. (4); 45 per cent. (6); 55 per cent. (7); 60 per cent. (8); 100 per cent. (10). The colour scheme is as follows:—white, ivory and natural yellow 00 to 09; brown 10 to 19; pink, red or mahogany 20 to 29; green 30 to 35; blue 36 to 39; grey to black 40 to 49; marbled 50 to 79; marked with spots 80 to 90.

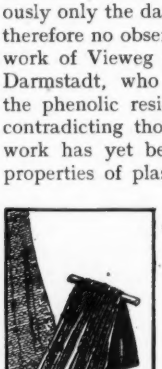
ELECTRICAL

Electric instrument manufacturers are finding plastics give considerable help in avoiding glare and shadows on instrument boards. Tillson ("Electrical World," November, 1941, p. 51) suggests transparent triangular covers which send the light from the

ceiling directly to the dial, or the mounting of a mirror perpendicular to the front of instrument, which sends reflected light into the dial housing. The triangular covers are to be made of thermoplastics, but these are soft and easily scratched, the portion of the cover facing the sight-line of the operator consists of a small piece of plate glass moulded into the plastic. In a new power plant some 800 instruments have been mounted in two galleries with gratifying results. In the case of low-level illumination, this idea may cause some difficulties on meters with rounded fronts, therefore, in these cases the metallic mirror has been adopted. In recent years miniature lamps, Lucite rods and, very recently, fluorescent lamps have been installed for illuminating dials. These devices are, at the moment, however, expensive for a large number of instruments, whilst the influence of heat radiating from the lamp dries the ink in recording instruments. Such difficulties were overcome by Lucite rods. The lamp is placed well back in the meter and a certain amount of light impinges on the inner end of the Lucite rod and travels through it as through a pipe, following the bends to the farther extremities where it emerges. However, two difficulties arise: the total light used for final illumination is very limited, whilst the rods are not very rigid, tending to sag and thus expose the rod, or direct the beam along a false path. A further article in the same journal (December, 1941) describes another system of fluorescent lighting for instrument panels by a false front, backed by polished parabolic reflectors, arranged to throw the light horizontally towards a special curved reflector in front of the hood. Name plates may be so illuminated simply by cutting a slot in the false front under each instrument and placing over it a piece of translucent material, bearing the name of the instrument. Lamicoid proved to be a very satisfactory plastic for this interesting purpose. (Lucite, a product of E. I. du Pont Nemours, is a polymethyl-methacrylate base similar to Perspex.)

AIRCRAFT

Fatigue properties of plastics are recorded in " Prevention of the Failure of Metals under Repeated Stress " (Battelle Memorial Institute). The book contains an interesting diagram and a table giving accurate data on the fatigue properties of acrylate resins (Plexiglas). The endurance strength of these materials remains nearly constant after about 5 million stress reversals, the fatigue limit lying between 0.23 to 0.39 of the tensile strength. The book is well illustrated, and contains about 146 references to scientific literature on the subject. Obviously only the data to 1940 are considered, therefore no observations are made on the work of Vieweg and his collaborators at Darmstadt, who investigated fatigue in the phenolic resins, and obtained results contradicting those given. Far too little work has yet been done on the fatigue properties of plastics.



TEXTILES

French production of rayon for 1941 is estimated at 31,000 tons compared with 27,700 tons for 1940. Through collaboration with German rayon manufacturers, it was possible to start the production of lanital in France, so that total production of artificial fibres may have reached during the past year a total of 52,000 tons. For 1942 a production increase to 100,000 tons is expected. In peace-time France consumed per year about 50,000 tons of raw textile products of which 80 per cent. was imported. Like Italy, France is trying to replace raw materials in short supply by the use of vegetable fibres, such as reed, broom, potato-haulms. To start such production,

obviously involving quite complicated and unorthodox processes, a running-in time of at least several years is necessary, so that at the present time imports must continue, but only for emergency purposes. Cellulose from reeds is now being produced on a large scale in Italy. After scientific investigations carried out over a number of years the Snia Viscosa has found it possible to produce cellulose from cultivated reed, and in the province of Fraul, a reed-cellulose plant has been erected directly in the swamp area in order to produce simultaneously the cultivated reed by modern agricultural method. It is intended to produce, up to 1944, 80,000 tons of cellulose in this way. To the end of 1938 about 3,000 acres of swamp area were planted with reed, but by 1940 it was possible to prepare another 3,000 acres for cultivation. In the last year of this plan, i.e., in 1944, it is intended to cultivate not less than 18,000 acres. The war has intensified efforts and the productive capacity of the modern cellulose plant at Torviscosa is said to be 65,000 tons cellulose per year. One-third of the reed supply could, even in 1940, be obtained from neighbouring plantations; this volume may have increased during 1941 to two-thirds of the supply. The remainder of the raw material for the work is, up till now, supplied by beech wood, but, in the near future, it may be fully replaced by cultivated reed. Italian experts are of the opinion that the cellulose produced from reed is superior to that produced from beech. In favour of reed it is stated that its productivity per unit area is about four times that of flax, and, compared with the cotton plant, about six-fold productivity is obtained. The following comparison data are based on figures given by Snia Viscosa:—Per year, one acre of cultivated reed produces about 0.7 ton fibre; one acre of hemp produces about 0.8 ton fibre; one acre of flax produces about 0.2 ton fibre; one acre of cotton produces about 0.15 ton fibre; one acre of forest fir or beech produces about 0.6 ton fibre. Cultivated reed reaches a height of 20 ft. and is harvested yearly.

MISCELLANEOUS

Shortages of metal for civilian purposes in U.S.A. could, it was hoped, be partially offset by a wider use of plastics. Such hopes have been shattered by H. M. Richardson, of the Plastics Department, G.E.C., who told engineers that in spite of the tremendous expansion in capacity of plastics plant in U.S.A., little would be left over for civilian uses after meeting the huge demands of war industries. Another difficulty is that several basic materials, such as formaldehyde, are now on the short list. Previous references in these columns on this point will, we fear, now need revising. **Tiny screws in watches** may become mixed when movements are dismantled, thus causing, on reassembly, damage to the sensitive components of the watch. A Swiss firm in the watch trade has produced pairs of plastic boxes, one round one, and one rectangular one. The round type, with a diameter of about 2 ins., has a small cylindrical aperture in the centre connected with the outer walls by six thin separation walls, resulting in a total of seven small containers. The rectangular box has external dimensions of $3\frac{3}{16}$ ins. by 2 3-32 ins. and is also divided by separation walls and a cylindrical wall into seven small containers, each of a different shape and size. This facilitates distinction between the different screws. The rectangular box is preferred for repairing work, whilst the cylindrical box is more suitable for storing purposes. **New plant for producing synthetic phenol** is in the course of erection in U.S.A., including a new one million dollar installation at the G.E.C. works, Pittsfield, Mass. It is probable that the plant will be opened in September, 1942, and will be in a position to produce about three-quarters of the G.E.C. requirements of phenol. Phenol and allied products are now placed under an amendment to General Preference Order M-27.

PRODUCTION NEWS

Raw Materials, New Plant, Works Organization, Control Apparatus, Research, Personal and Trade Notes

ENGINEERING BULLETIN.—The most recent of this publication (No. 9) of the Ministry of Labour and National Service contains some interesting revelations regarding the absorption into industry of Government trainees, both male and female. An example is given of the creation of a small factory making jigs and tools using two skilled fitters and one turner as a nucleus. The staff has now been increased to 50 and is composed of three skilled workmen, four semi-skilled, four dilutees, 31 trainees (six women), four apprentices and four unskilled. Only one trainee has proved unsuitable, and additional women are to be engaged for turning, drilling and fitting.

There is another excellent illustrated article entitled "Women Build Marine Engines," a story of how the shortage of labour is being overcome on Clydeside by training on the job. Yet another describes the entry of women labour into a factory dealing solely with the rebuilding of crashed aeroplanes. Finally, there are extremely useful hints and guides on "How to Break In a New Man," a facet of industry that normally is almost always neglected.

PLYWOODS.—The plastics industry is now, in a sense, wedded fairly closely to the plywood industry and on its future depends the welfare of a very important section of our industry—the resin glues and impregnating solutions. It should therefore welcome the issue of a new work entitled "Plywoods," by A. D. Wood and T. S. Linn, and published by W. and A. K. Johnston, Ltd., Easter Road, Edinburgh, at 25s. net. The authors are obviously highly competent with a very complete knowledge of the industry, its historical development, manufacture and application. The book is beautifully produced and illustrated.

In a special chapter devoted to adhesives, the writers discourse lengthily on all the modern synthetic resins that have now become part and parcel of plywood manufacture. Bakelite, Beetle, Catabond and Kaurit glues are carefully examined and the best methods and conditions of use and resulting strengths discussed. Excellent photographs of houses and petrol-filling stations built in the U.S.A. from resin-bonded plywood are included. One extremely interesting story which plywood manufacturers in this country might digest is that told about the International Exhibition of 1940 on Treasure Island, San Francisco. During August of that year a serious fire broke out in the California building, and it is on record that after burning through 1-in. diagonal wooden sheathing on the inside face of the wall-studs, the fire was actually checked by the $\frac{7}{16}$-in. resin-bonded Oregon pine plywood exterior panels. The fire was confined to a single building and, in the opinion of both Exhibition authorities and insurance inspectors, if the roof had also been of resin-impregnated plywood construction the fire would have been subdued within the room in which it started. The heat had little effect on the resin bond and the rate of charring was greatly reduced owing to the absence of all tendency to ply separation.

NAPHTHA AND XYLOLE ORDER.—The Secretary of Mines announces that in pursuance of Regulation 55 of the Defence (General) Regulations, 1939, the Board of Trade has made the Coal Tar Naphtha and Xylole Order, 1942. This Order has been published as a Statutory Rule and Order (S.R. and O. 1942, No. 218) and came into operation on March 1, 1942.

The Order provides that no person shall dispose of coal tar naphtha and xylole in quantities exceeding the amounts quoted in the Schedule except under licence. The Secretary for Mines may also give directions regarding the disposal, treatment, use and blending and, in certain circumstances, fix prices in respect of, coal tar naphtha and xylole.

Applications for Disposal Licences should be addressed to the Mines Department, Dean Stanley Street, Millbank, London, S.W.1.

BAKELITE, LTD., have placed on the market two sealing solutions, Bakelite V1845 and N2106, for treating porous castings so as to render them, after processings, pressure-tight and thereby serviceable.

WILD BARFIELD JOURNAL.—Those concerned with tool construction will always find something of interest in this pamphlet. The September-December, 1941, issue contains three special articles dealing with "Polarized Light in Metallographic Examination," "Controlled Oil Quenching," and "Absorptiometric Analysis."

NEW CELLULOSE FIBRE.—The rapidity with which new fibres are now being made has transformed the textile industry almost into a chemical one. The more recent developments have tended towards the purely synthetic type, but research on what is now called the "older" man-made form still goes on and with profit. Mr. C. Diamond reports the production of a new cellulose fibre which can be made into rayon by a process which follows the manufacture of viscose up to a point.

As is well known, viscose is made by treating wood or paper pulp with soda and the organic solvent, carbon bisulphide. This forms an orange-coloured crumby material which undergoes further treatment and is spun into an acid bath where the cellulose is regenerated. In other words, the original cellulose is merely transformed into a spinnable variety. By the new process the orange-coloured half-stage material (called xanthate) is treated with aniline and sodium chloracetate. The new product is dissolved in soda, and this, too, can be spun into an acid bath. The difference between the new fibre and viscose is that the former is not regenerated cellulose, but now contains sulphur and nitrogen, thus giving it great affinity for acid dyes—an improvement over the old viscose.

BOARD OF TRADE NOTICES

1. The Board of Trade have, with the approval of the Treasury, decided that, in respect of the period beginning March 3, 1942, and ending June 2, 1942, the rate of premium payable under any policy of insurance issued under the Commodity Insurance Scheme shall continue to be at the rate of 7s. 6d. per cent. per month.

2. The Board of Trade have made the Export of Goods (Control) (No. 11) Order, 1942 (S.R. and O., 1942, No. 367, price 1d.), which came into force on March 6. Under the terms of this Order export licences will in future be required for all goods consigned to Burma. At the same time the Board of Trade have issued an Order revoking all outstanding export licences for Burma. (S.R. and O., 1942, No. 368, price 1d.) Copies of the Orders will be available at H.M. Stationery Office and through booksellers shortly.

BRITISH INDUSTRIAL PLASTICS, LTD.—The balance-sheet shows the great activity of this company, for a new record in gross profits (£169,000) is reached. Research, depreciation and pensions account for more than £23,000 normal expenditure, whilst abnormal expenditure, that is war insurance, air-raid precautions, Army allowances, account for £11,000. After setting aside the sum of £71,000 for taxation, the net profits are £15,989 6s. 9d. The dividend for the year on the ordinary shares is 6 per cent. At the ordinary general meeting, Mr. K. M. Chance said in his speech that there has, in the past, existed some misconception of the true rôle of plastic materials. With the exception of the electrical market, plastics have too often been classed as substitutes and, as Mr. Chance said, "frequently poor ones at that." It is becoming increasingly recognized, however, that plastic manufactures exceed in both utility and appearance much that the older industries can supply. There can be no doubt that the plastics industry will become increasingly important. And the British Industrial Plastics group will play its part in developments yet to come.

BRITISH PLASTICS FEDERATION.—We are informed that after March 20 the Federation offices will be removed from Pall Mall to 47-48, Piccadilly, London, W.1. The telephone number is Regent 4681-2.

ERINOID, LTD.—Mr. Robert Dodd, who has been connected so long with this company and has been its acting general manager, has now been made a director.

DR. HARRY BARRON, who broadcast a talk on February 6 on "Synthetic Rubber," is head of the Plastics Department of Pirelli-General Cable Works, Ltd., and a member of the Plastics Panel of the Cable Makers' Association. He is the author of "Modern Rubber Chemistry."

The fact that goods made of raw materials in short supply because of war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

INQUIRIES AND ANSWERS

(In Which is Included General Correspondence)

IMPORTANT NOTICE: If inquirers wish to receive replies by post, a stamped and addressed envelope must be included in their letter. Unless otherwise stipulated, it is understood that the submission of a problem to the Editor permits its publication in this journal.

Polyvinylidene Chloride

We have read with interest your article in the January issue on new material called "Saran." We are anxious to have samples of this material and we would like to know if it is being produced in this country. If not, would you kindly indicate where we may be able to obtain samples? C.P., LTD.

Chelmsford.

[EDITOR'S NOTE.—Several inquiries have been received about Saran, the polyvinylidene chloride made by the Dow Chemical Co., Inc., of U.S.A. We have no knowledge yet of the agents in this country, but the inquirers may care to get into touch with Monsanto Chemicals, Ltd., or R. W. Greeff and Co., Ltd., who represent the American concern for other materials it manufactures. It is extremely doubtful that Saran will be developed here during war-time.]

Catalogue of Plastics

Reference your February issue of "Plastics," I note on p. 18 a reference to a supplement to "Machine Design," October, 1941, which catalogues the properties of about 170 plastics. Unfortunately I cannot trace the address of the publishers of "Machine Design" and I should be grateful if you would help me either by sending me their address or, if possible, a copy of the supplement in question. The matter contained therein would be of invaluable assistance to me in lectures given to officer specialist courses at this college.

MILITARY COLLEGE OF SCIENCE.

[EDITOR'S NOTE.—"Machine Design" is an American journal published by the Penton Publishing Co. Cleveland, Ohio, and is dealt with here by the same company at 2, Caxton Street, Westminster, S.W.1. We have seen a copy of the issue in question and fear that the article, while very useful, is not as comprehensive as is indicated by the statement that it deals with 170 plastics since they are listed by trade names and is therefore repetitive.]

Fastener Pins in Plastics

We have been asked to produce our patented fastener pins in suitable rag-filled plastic mouldings for use on aircraft where they are liable to come in contact with electrical equipment. It is necessary, therefore, that they are made in a non-conducting material. Perhaps you would be kind enough to give us the names of

firms which you think would be capable of undertaking this job.

For your information, we are enclosing a sample of an existing pin made in steel which we would like replaced by a plastic moulding. O.B. AND C., LTD.

Eastleigh.

[EDITOR'S NOTE.—Obviously the job of making this pin (the drawing is actual size) can be carried out by machining from laminated block or by moulding. Which will be adopted will probably depend on the number required. There is also the problem of the slot in the head which is probably only for positioning. As it stands, it seems that a split mould would be necessary. Any suggestions will be gladly passed on to the inquirers.]

Casting Polymer Films

We wish to carry out some work on an experimental scale with regard to the casting of films. These film materials are of the vinyl family and we wondered whether you know of a firm who could carry out the film casting on a small scale or whether there are any small machines manufactured which might be suitable for

producing film from some of our experimental batches of solution.

Bristol, 1. R.O. AND CO., LTD.

[EDITOR'S NOTE.—It is possible that one of the large manufacturing concerns may help in research work of this type. Alternatively, the inquirer might approach one of the smaller concerns who have been engaged in film work. It is also possible that makers of casting or film coating machines may care to help. Names have been forwarded to the inquirer.]

Extruded Thermoplastics

We enclose a small sample of a plastic known as "Permalon," which is manufactured by the Pierce Plastic Inc., Bay City, Michigan, U.S.A., and we are wondering if you could advise us if there are any manufacturers of a similar material in this country; if so, we should like to contact them. E.T.M. CO., LTD.

Manchester, 17.

[EDITOR'S NOTE.—While we know the trade name Permalon we do not know its composition without carrying out a proper analysis. The Pierce Plastic Inc. do not appear to make the raw material, but extrude strips, webbing, tubes and thread from it. The material is thermoplastic and contains chlorine. Judging from the odour on heating it is probably polyvinylidene chloride. If the latter, see the first letter on the previous page. Otherwise there are manufacturers and extruders of polyvinyl chloride and polythene in this country.]

Decolorizing Acetate Sheet

We wish to inquire if there is any process known to remove the blue tint from acetate sheet leaving the material transparent and white. The tint appears to be on the surface. Our process removes the tint in patches. L.

[EDITOR'S NOTE.—We regret that we do not know any method by which the removal of tint can be carried out efficiently and evenly. Both tinting in the mass and surface tinting are practised, the latter rarely, for obviously surface tinting would tend to give poor results since it must be done by dipping. From the appearance of the sheet it would seem that the colour exists throughout the thickness. If the inquirers have had poor results using a solvent such as acetone, the latter has probably dissolved the acetate unevenly and given an apparent removal of colour only. Ultra-violet light undoubtedly affects colour and would probably remove the blue tint. Unfortunately it would almost certainly decompose the acetate and produce an unsightly brown colour.

The only suggestion we can make, therefore, is that the tinted material should be returned to the manufacturers and sold for scrap and the non-tinted variety bought.]

Testing of Plastics

We find the greatest need of a book dealing comprehensively with the chemical analysis and physical and mechanical testing of plastics in our work. While we recognize the difficulties of producing such a book during wartime, we should be glad to know the chances of it appearing.

Manchester. J.C.J. AND SONS.

[EDITOR'S NOTE.—There is, indeed, a great need for such a book, coupled with a list and discussion of the various specifications that have been laid down in various countries, since the official tests and specifications are so much a part of the system. In many cases new methods of testing not so closely allied to those applied to older materials of construction are very necessary. We have some information that two well-known plastic technologists are about to produce a book of this nature. When it does it will be a landmark in the history of the industry.

Availability of Plastics

We have received an inquiry from customers in S. Africa for supplies of polystyrene resin for injection moulding of electrical units. Can you give us some information regarding this product?

London. O., LTD.

[EDITOR'S NOTE.—There is so great a need for this material for direct war purposes that it is extremely unlikely any will be allowed out of the country. The inquirer should write to the Ministry of Supply, Plastics Control, The Burgh, Epsom, Surrey.]

Resinoids and Other Plastics as Film Formers

By B. J. BRAJNIKOFF,
Consulting Electrical Engineer

VI.—The Role of Polyvinylchloride Resins in Surface Coatings

THE possibility of producing an amorphous substance of the resinous type from vinyl chloride has been known for a long time.

Regnault,[21] had observed, in 1838, three years after his discovery of vinyl chloride from the reaction of dichlorethane with alcoholic solution of caustic potash, the formation of vinyl chloride polymers, as a white powder, under the action of sunlight in sealed glass tubes.

However, for Regnault and his contemporaries this phenomenon had been merely a curiosity among various transformations of organic combinations and possessed not the slightest practical value.

Early Research

The technical appreciation of polyvinylchlorides, as polymeric products based upon vinyl chloride are generally termed, has been the result of labours of a number of pioneers, beginning with Bauman,[22] who in 1872 succeeded in polymerizing the vinyl halides to white viscous plastic masses "unaffected by solvents or acids."

In this field the researches of Ostromislensky[23] are of special interest and importance; as far back as 1912 he pointed out the conditions for the polymerization of vinyl chloride, vinyl bromide or their methyl homologues, and the methods for obtaining from their polymers, rubber-like or similar substances, as for example, "celluloid-, ebonite, and gutta-percha-like materials."

In his inquiries Ostromislensky endeavoured to establish the difference between the polymers of vinyl chloride, which he termed "cauprenechlorides," and chlorinated rubber.[24]

He found this identity in an elementary compound, which was determined by him as $C_{32}H_{48}Cl_{16}$ for the vinyl chloride polymers as well as for the chlorinated synthetic Cutadiene rubber, and as $C_{32}H_{40}(CH_3)_8Cl_{16}$ for the chlorinated and isoprene synthetic rubbers.

The solubility of the above-mentioned compounds in acetone, chloroform, chlorbenzol, naphthalene, and insolubility in alcohols, glycols, glycerine, and also their ability to be transformed into celluloid-, ebonite-, and gutta-percha-like masses, were regarded by Ostromislensky as indices confirming the identity of polymeric products of vinyl chloride with chlorinated Cutadiene, isoprene, and natural rubbers.

Thus, 30 years ago Ostromislensky showed the possibility of the industrial utilization of the vinyl chloride polymers, and in a series of practical examples gave the technique for performing the polymerization processes.

Reactions of Vinyl Chloride

Vinyl monohalogenides, $CH_2 = CH.X$, of which the vinyl chloride is the leading representative, form a highly important group of materials that offer many interesting possibilities as a prolific source of various synthetics of outstanding merit.

Vinyl chloride, $CH_2 = CH.Cl$ (molecular weight 62.48), may be obtained either as a monohaloid derivative of ethylene, or as the result of uniting acetylene with hydrogen chloride by passage over a contact catalyst. Its unsaturated character, conditioned by the presence of a double bond, allows the realization of numerous reactions.

At normal temperature vinyl chloride is a colourless gas, condensing into liquid at −12 degrees to −14 degrees C. In admixture with acetone (1:1) the vapour

pressure of vinyl chloride decreases almost twofold.

As has been demonstrated by various workers, vinyl chloride, under the influence of different factors, such as time, temperature, pressure, light, purity of monomer, nature of catalysts and modifying agents, mechanical conditions during the reaction, may yield polymerized products, which are capable of displaying a great variety of chemical and physical properties.

Owing to low mobility of the chlorine atom in these polyvinylchloride derivatives, the problems of their technological treatment are facilitated, particularly those involving the application of relatively high temperatures and pressures.

Vinyl chloride with chlorine forms 1, 1.2-trichlorethane. In presence of aluminium chloride as well as chlorides of zinc and iron, at 0-35 degrees C., it adds hydrogen chloride with the formation of ethylidene chloride.[25]

Polyvinylidene Chloride Plastics

The other group of combinations, known as polyvinylidene chlorides, is a fertile source of new compounds which are specially adapted for producing different film-forming agents with exceptionally valuable characteristics. Coatings derived from polyvinylidene chlorides display the outstanding properties of highly strong resistance to chemicals and solvents, low absorption of water, and the dimensional and colour stability; for instance, a test specimen of a film, 0.001 in. thick, made from vinylidene chloride polymers, as issued in 1940 by the Dow Chemical Co., under the trade name of Saran, showed the resistance to moisture penetration 500 per cent. greater than that of the best organic coating available on the market, transmitting only 1.3 grams of water vapour per square metre in 24 hours at 45 degrees C.

A number of polyvinylchloride coating compounds, as developed in Russia since 1939 by the Institute of the Organic Chemistry of the Academy of Sciences, proved to be no less remarkable. These compositions, which are designed exclusively for technical purposes, yield films with extremely valuable features: almost complete insensibility to water (the tensile strength in the dry and wet state is identical), non-inflammability, immunity to nearly all acids and alkalis, and dielectric and thermal properties higher than those of any commercially known coatings.

The study of results already achieved during the past five years from application of polyvinylchlorides, as shown, for example, by the performance of Koroseal in the U.S.A. and its British and German analogue Mipolam, provides conclusive proof that there is every reason to expect from this source new interesting possibilities for developing coating media, particularly of the anti-corrosive type.

The polymeric products of vinyl chloride used either alone or in conjunction with other components, mainly with vinylacetate, widen still farther the sphere of their utility.

The thermo-plasticity of such compounds permits the application of film-forming media in several ways, namely: (a) by means of a spray-gun, (b) in a solution form, and (c) as synthetic latex systems, allowing electro-deposition of coatings.

Hence, resinous products, based on vinyl chloride, due to possession of great mechanical and chemical stability, elasticity, transparency, capacity for combining with pigments, non-inflammability, resistance to frost down to −50 degrees C., high dielectric and adhesive properties, etc., are obvious materials that can be used to advantage in many arts and crafts, especially in the coating field.

Production of Vinyl Chloride

In view of a large variety of polymeric products derivable from the vinyl chloride, the methods of its manufacture are, naturally, of great practical interest and importance.

There are three principal methods for obtaining vinyl chloride on the industrial scale.

1.—Manufacture of Vinyl Chloride by Hydrolysis of Dichlorethane.

This process is based on the reaction:
$CH_2Cl - CH_2Cl + NaOH \longrightarrow$
$CH_2 - CHCl + NaCl + H_2O$.

The raw materials required by this procedure are the commercial dichlorethane, caustic and alcohol (ethyl or methyl), which are brought together in definite proportion. The first ingredient to go into the reaction apparatus, which may be an iron or cast-iron jacketed vessel fitted with a stirrer, is an alcohol solution of caustic soda, following by a gradual admission of dichlorethane. The temperature is kept within appropriate limits, being regulated by hot water circulated through the jacketed walls of the plant.

Care should be taken to guard against overstepping an optimal temperature level lest the released vinyl chloride will entrain an azeotropic mixture (dichlorethane, ethyl alcohol and water) having a higher boiling point.

The process, which is conducted under suitable pressure, with the constant agitation of the reaction mix. results in a rather uniform formation of vinyl chloride, and is completed in four-five hours.

By augmenting the charge of the alcohol constituent the procedure is accelerated. The presence in the reactor of a large volume of water gives rise to the formation of a certain quantity of ethyleneglycol. To avert this resort may be made to the use of concentrated alkali or even dry caustic. With the excess of caustic component, the reaction is accompanied by the evolution of the undesirable by-product—acetylene (although in a negligible amount).

The residue left in the vessel, on the completion of the process, in the form of alcohol solution of alkali and the excess of dichlorethane (after the removal of salt and appropriate treatment), may be employed again. The yield of vinyl chloride by this method reaches 75-85 per cent. of dichlorethane used.

The reaction of splitting off of hydrogen chloride from dichlorethane can also be carried out in an aqueous alkali solution, under increased pressure and at the temperature 85 degrees-90 degrees C.

Vinyl chloride produced by hydrolizing dichlorethane should conform to the requirements:—(a) The vinyl chloride content should be not less than 90 per cent. by volume; (b) the boiling point range from -10 down to -15 degrees C.; and (c) non-volatile residue up to 100 degrees C. not over 1.5 per cent. by weight.

2.—Production of Vinyl Chloride by the Pyrolysis of Dichlorethane.

The bulky plant equipment required in the making of vinyl chloride by the preceding method induced the technologists to work out a means for obtaining this valuable product obviating the use of alcohol and caustic, and performable in an apparatus that ensures continuous procedure.

This is readily accomplished by pyrolysing dichlorethane in the presence of a suitable catalyser.

Dichlorethane vapours at high temperature are passed over a catalyst according to the reaction:—
$CH_2Cl - CH_2Cl \longrightarrow CH_2=CHCl + HCl$.

Such a process, which has been recently a focal point of a series of patents, may be effected by the application of various catalysts and within a considerable temperature range. For instance, an excellent yield of vinyl chloride is obtained by passing dichlorethane vapours over activated carbon at 240-350 degrees C.

Notwithstanding, however, the obvious advantages offered by this method in the economy of both the raw materials and the continuous type of operation, the process so far has not met with the due appreciation in industry.

The requirements, which vinyl chloride produced by pyrolysing dichlorethane, should satisfy, are:—(a) Vinyl chloride content minimum 92 per cent.; (b) acetylene content in a gaseous phase not more than 2 per cent. by volume (which corresponds to 1 per cent. by weight); (c) non-volatile residue up to 20 degrees

C. not over 1 per cent. by weight; and (d) the boiling temperature from – 10 degrees to – 16 degrees C.

3.—Production of Vinyl Chloride from Acetylene.

The process of manufacture of vinyl chloride from acetylene actually consists of effecting the union of hydrogen chloride with acetylene in presence of a catalyst.

The patent literature relating to synthesizing vinyl chloride from acetylene may be summed up in a fundamental formula of passing acetylene and hydrogen chloride, compressed up to 1-1.5 atmospheres, over a contact catalyst. The main points of difference among many variants of this method being the distinction in the temperature range, selection of catalyst and the plant equipment required by the procedure.

The synthesis of vinyl chloride by this method is realized according to reaction: $C_2H_2 + HCl \longrightarrow CH_2=CHCl + 477$ calories.

The temperature level, with liquid catalysts, in the majority of cases is maintained within 60 degrees to 80 degrees C. The hydrochloric acid solutions of metal chlorides are the catalysts used in the process.

The following reagents are recommended for application as dry catalysts: (a) mercury chloride (corrosive sublimate) precipitated on silicagel; in this case the process of obtaining vinyl chloride may be performed at reduced temperature range of 20 degrees to 30 degrees C.; (b) activated carbon; here the reaction is conducted at the temperature level up to 200 degrees C.

The yields of vinyl chloride computed on the basis of acetylene are usually of the order of 55-70 per cent., and an additional heat economy in the process can be effected by utilizing exhaust gases through their recirculation.

Judging by the profusion of American patent specifications for deriving vinyl chloride from acetylene, it is evident that this method is definitely favoured by the plastic industry in the U.S.A.

It is also worth while noting that the rapidly expanding use of the acetylene process for vinyl chloride synthesis in America is very closely followed by a similar tendency in Germany. In that country the great reactivity of vinyl chloride, yielding derivatives of far-reaching technical and strategic importance, has been duly assessed and of late speedily translated into a large-scale manufacture.

The vinyl chloride produced by the acetylene method must fulfil the conditions: (a) the vinyl chloride content should not be less than 94 per cent. by volume (corresponding to 97.5 per cent. by weight); (b) acetylene content in a vapour phase maximum 4.5 per cent. by volume (which makes 2.2 per cent. by weight); (c) non-volatile residue up to 100 degrees C. not over 1 per cent. by weight; and (d) boiling-point temperature from about – 10 degrees to – 15 degrees C.

The primary requisite of the liquid vinyl chloride should be its chemical purity.

Irrespective of the method for manufacture of the vinyl chloride, this product must not contain an alkali, for, in presence of the latter, it might give explosive mixture (due to formation of acetylene).

Vinyl chloride is a commodity quite amenable to transportation, and may conveniently be carried in steel bottles fitted with a siphon (of the type of chlorine bottle), in special iron barrels, and in the railway tank-cars. The steel of containers, and particularly slight films of iron oxide on their interface, exert upon vinyl chloride somewhat stabilizing influence and retard its self-polymerization.

Polymerization Methods

Fundamentally, there are two general ways for obtaining polymers of vinyl chloride: (1) Photochemical requiring no catalytic aid, and (2) thermal, with the application of catalysts in a suitable medium. The photochemical method of preparing polymers is as old as the vinyl chloride itself.

The first experiments connected with the derivation of vinyl chloride polymers and the conditions of their preparation, had been conducted with the help of the photochemical influence on the monomer.

Regnault, Bauman and Ostromislensky for polymerizing the vinyl chloride applied sunlight and ultra-violet rays.

The detailed conditions of the photo-polymerization has been studied by Ostromislensky in Russia.

According to his patents, the polymerization is effected irradiation from a mercury quartz lamp for 12 hours at 20 degrees C.

Ostromislensky classifies the resultant polymers as alpha —, beta —, gamma —, and delta —, polyvinylchlorides, according to solubility in acetone or chlorbenzol: α—polymer is soluble in acetone; β—polymer is soluble in chlorbenzol; γ—, and δ—polymers are insoluble in chlorbenzol.

In the opinion of Ostromislensky, in the photo-polymerization the process progresses with formation at first α—polymer, which, under the continued action of ultra-violet rays, is converted into β— form; the transformation of vinyl chloride into γ— and δ— polymers is conditioned by a further prolonged action of the ultra-violet radiation.

In order to ensure a high degree of dispersion of polyvinyl chloride molecules the photochemical process, like the thermo-polymerization, may be conducted in appropriate media, either (i) in a solvent (e.g., alcohol, acetone, dichlorethane, etc.), or (ii) in water emulsions.

The problem of the photo-polymerization of vinyl chloride in various solvents has been investigated by Plotnikoff,[27] and the colloidal properties of vinyl chloride polymers derived in different solutions were examined by Flumiani.[28]

The results of these researches showed that the speed of polymerization of vinyl chloride in solution, at its constant concentration, depends on the nature of a solvent; for example, the comparative values of polymerization velocities in toluol medium is 1, in ethyl alcohol 25, and in carbon tetrachloride 68, the last solution yielding photo-polymers particularly interesting from the colloidal standpoint (as oily or gluey compounds).

The effect of the ultra-violet rays upon the liquid vinyl chloride is so intense that the formation of polymers is taking place almost spontaneously. It would seem, therefore, that out of numerous methods the photo-polymerization of vinyl chloride has the most favourable chances of application, since it allows the continual procedure, with great speed.

However, due to difficulty of regulating this process, its application is much hindered, and a wider use of such a method depends upon a further study and elucidation of the factors controlling the reaction, which is, clearly, the problem for concerted attention of an organic chemist and electrophysicist.

For this reason the polymerization under the action of heat is preferred.

Thermopolymerization

Under the influence of heat the vinyl chloride readily polymerizes to form resinous substances varying in properties over an extensive range, from rubber-like plastics to hardest solids.[29]

Most diverse reagents have been proposed for the use as catalysts in thermo-polymerization of vinyl chloride. It has been suggested, for instance, in Germany to catalyze the reactions with the aid of salts of uranium, cobalt and lead.[30]

The Carbide and Chemical Co.,[31] U.S.A., employs tetraethyl lead. Du Pont Co.[32] polymerizes vinyl chloride by heating it in conjunction with ozonized 90 per cent. methyl alcohol.

Lawson[33] recommends the application of small amounts of benzoyl peroxide for polymerization in chlorbenzol medium conducted in a tin-lined vessel under pressure of 15 atmospheres at 118 degrees C.; the polymer is insoluble in toluol.

Alpha-polymer[34] may be obtained by polymerizing vinyl chloride at 90 degrees-120 degrees C. in the following solvents: methyl alcohol, dichlorethane, chlorbenzol, ethylacetate, benzol, acetone, toluol, in presence of benzoyl or barium peroxides, or ozone, as catalysts.

The polymerization may be accomplished as well in the solution[35] of methanol, ethanol, pentane, hexane, acetone, aromatic hydrocarbons (viz., toluol, xylol), in presence of oxidizing catalysts at 40 degrees C.

The polymerizing process may also be performed with the aid of two catalysts,[36] one of which is of oxidizing character (ozone, peroxides of hydrogen, barium, benzoyl), and the other is an unsaturated polymerizable compound (butadiene unsymmetric dichlorethylene, trichlorethylene formaldehyde). In such cases the product is gamma-polymer.

The polymerization carried out in alcohol or benzene medium results in finely dispersed polymeric products.

The Rôle of Media

From the foregoing analysis it is easy to deduce that, besides photo-polymerization, numerous ways for polymerizing the vinyl chloride are reducible to two basic procedures: I, Polymerization in emulsions, and II, Polymerization in solutions.

I. Emulsion Polymerization

In this process the polymerization of vinyl chloride is conducted in the medium of water in the presence of catalytic and emulsifying agents. Benzoyl peroxide may serve as a good catalyst in this as well as other reactions, and sodium salt of isobutylsulphonaphthalene acid ("nekal"), triethanolamine soap and the like—may be adopted as emulgents.

The ingredients, in definite ratio, are charged in the following order: first to be admitted into the autoclave is water in presence of emulgent, then vinyl chloride, and finally a catalyst in aqueous suspension (or in acetone solution) introduced gradually in order to avert an untimely deoxidizing action.

An average duration of the procedure, is 65-75 hours.

A variant of this method is the polymerization carried out in a water phase, dispensing entirely with emulsifying agents, using higher catalyst content and a temperature of 55 degrees C.

II. Polymerization in Solutions

The polymerization of vinyl chloride in the medium of alcohol (ethanol, methanol), dichlorethane, acetone, etc., differs from the emulsion method in that it uses a suitable solvent as the dispersing phase in place of water, due to which the process requires no emulgents.

For example, in the event of using alcohol, the procedure is: the components, taken in certain proportions, are charged into the reaction vessel starting from alcohol, followed by vinyl chloride and a catalyzer in the form of 10-15 per cent. solution (preferably in acetone). At 50 degrees C. the process takes 80 hours.

Plant Equipment

An autoclave for polymerizing vinyl chloride both in the emulsions and solutions should be designed for operations under pressure and fitted with an agitating device ensuring vigorous stirring of the liquid during the reaction.

With the object of neutralizing the known property of iron and its oxides of stabilizing action upon vinyl chloride impeding its polymerization, the reactor should be either homogeneously lead-lined, or aluminium-coated (e.g., metallized by a spraying pistol).

Production of Synthetic Latices

The polymerization of vinyl chloride in emulsions, with the aim of obtaining latex-like systems or polymers with improved physical and mechanical properties, considerably extends the sphere of utility of polyvinylchlorides and other related resinoids, through electro-cataphoretic deposition of films on metals.

Typical data on the preparation of artificial latices from polyvinylchlorides by the latest polymerization procedures may now be instanced: first of all note should be made of the proposal[37] to polymerize vinyl chloride in emulsion by heating in presence of benzene and products of reaction of ethyleneoxide with a mixture of hydrated fatty acids and coconut emulgent.

Another method[38] recently developed

for producing latex-like media is realized by polymerizing vinyl chloride in aqueous emulsion, in presence of vinyl esters of carbonic acids (e.g., acetic, chloracetic), under the influence of chemically active rays, with ozone, benzoyl or acetyl peroxides as catalysts, under pressure up to 30 atmospheres and at 40 degrees-55 degrees C.

If required, the salts of alkaline metals of low-molecular organic acids may be employed as effective coagulants for precipating and agglomerating the above synthetic latices.

It should also be recalled, moreover, that the application of the electrochemical coating process is not confined to metal bases; under appropriate conditions it can be used just as effectively for depositing protective insulating layers of resinous materials from emulsions upon any substance, including non-metals.

Thus, for exampie, by imparting to wood, paper, leather or other fabric, an electro-conducting surface by impregnating them with electrolytic solutions, they can be made to serve as electrodes (e.g., anodes) for receiving deposition of resinous particles, moved by the electric current and forming a strong coherent layer.

By depositing synthetic latices on forms of fusible matter (viz., wax), whose periphery wholly or partly was previously treated with a conducting surface (e.g., graphite), a large variety of useful objects may be prepared including hollow articles, such as technical gloves.

Co-polymers

Resinoids of the polyvinyl group derivable via cross-polymerization opens up a source of great promise for obtaining hybrid products.

Co-polymers may be produced by applying any of the methods as described above, by simultaneous polymerization of the vinyl chloride with other polymerizable substances (e.g., vinylacetate, vinyloleate in ratio 80 : 20, 85 : 15, etc.).

Polyvinylchloride resins of both the individual type and co-polymers should conform to various requirements depending upon the object in view.

Thus, whereas one of the prime conditions of polyvinyl resins to be used in coating media is the reduced viscosity, a polymer required in the making of the electric cables should have an increased temperature of decomposition (140 degrees-150 degrees C.), maximum moisture content 0.2-0.3 per cent., etc.

The average technical requirements of polyvinylchloride resins are as follow:—

The relative viscosity at 20 degrees C. (by Ostwald test) from 0.16 to 0.12; the temperature of decomposition of resin not lower than 130 degrees-150 degrees C.; the moisture content (by Dien-Stark test) not above 1-1.5 per cent.; the chlorine content (by Carius test) not below 52.5 per cent.; the solubility in acetone not greater than 35 per cent.; ash-content not over 0.3 per cent.; volatile matter not above 0.5 per cent.

It should be borne in mind that in the selection of a polymerization method, constant attention must be paid to functions for which a product is projected, since resinoids prepared by various processes are essentially different in their chemical and physical features. This aspect and its ramifications with film-formation and the performance of coatings, will be discussed in the next section of the current work.

(To be continued)

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